MONTHLY WEATHER REVIEW.

Editor: Prof. Cleveland Abbe.

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INTRODUCTION.

The present summary for 1903 is based essentially upon data received from about 166 regular Weather Bureau stations, 33 regular Canadian stations, and from such climate and crop sections as have forwarded their annual summaries in time. The statistical tables and charts have been prepared under the supervision of Mr. W. B. Stockman, District Forecaster, in charge of the Division of Meteorological Records; the tables of movements of high and low areas by Mr. George E. Hunt, Chief Clerk, Forecast Division; and the summary of flood movements by Dr. H. C. Frankenfield, District Forecaster.

FORECAST DIVISION.

Prof. E. B. Garriott, in charge.

HIGHS AND LOWS OF 1903.

The high and low data for the year 1903 have been compiled under the general plan followed since 1895, and they differ but slightly in their general features from those of the preceding eight years.

The tables herewith give the summary for each month of the year 1903, and likewise a summary for the nine years from 1895 to 1903, inclusive.

Summary of highs and lows for 1903.

Month.	Highs.							Lows.						
	Mean first observed.		Mean last observed.		Path, average.		Hourly velocity.	Mean first observed.		Mean last observed.		Path, average.		Hourly velocity.
	Lat. N.	Long. W.	Lat. N.	Long. W.	Length.	Duration, days.		Lat. N.	Long. W.	Lat. N.	Long. W.	Length.	Duration, days.	
	°	°	°	°	Miles.			°	°	°	°	Miles.		
Jan	47	112	35	76	2,556	3.1	36.0	44	110	44	67	2,565	3.0	35.7
Feb	48	115	37	74	2,591	4.0	27.8	40	114	46	61	3,168	4.2	31.8
Mar	50	116	44	63	3,164	4.6	29.4	37	104	44	72	2,025	2.7	32.8
April	48	113	43	90	1,845	3.5	21.9	44	113	44	73	2,378	3.6	29.9
May	47	112	48	70	2,475	3.2	32.6	37	114	40	80	2,282	4.9	20.1
June	47	118	43	93	2,044	3.5	26.2	42	106	42	82	1,914	3.6	24.6
July	47	112	38	81	2,456	4.6	23.2	42	110	46	74	2,278	3.6	27.0
Aug	50	113	42	66	3,046	5.4	24.6	43	110	44	70	2,403	3.9	25.8
Sept	48	119	41	69	3,618	5.5	27.7	39	99	44	64	2,625	4.2	26.1
Oct	43	120	42	75	3,294	4.9	29.0	43	107	45	66	2,803	4.3	29.5
Nov	50	113	37	77	2,650	4.0	30.9	47	110	44	74	2,225	2.8	35.5
Dec	47	108	37	78	2,460	3.4	31.6	46	111	46	65	2,736	2.9	39.3
Means	47	114	41	76	2,683	4.1	28.4	42	109	44	71	2,450	3.6	29.8

Summary, 1895 to 1903, inclusive.

Year.	Highs.					Lows.				
	Mean first observed.		Mean last observed.		Hourly velocity.	Mean first observed.		Mean last observed.		Hourly velocity.
	Lat. N.	Long. W.	Lat. N.	Long. W.		Lat. N.	Long. W.	Lat. N.	Long. W.	
	°	°	°	°	Miles.	°	°	°	°	Miles.
1895	47	110	39	80	24	45	107	45	73	26
1896	48	111	42	75	24	46	111	46	74	26
1897	48	113	38	78	24	46	110	46	71	26
1898	46	114	40	72	25	45	111	46	67	26
1899	47	114	41	72	24	44	111	46	68	27
1900	46	108	42	75	28	44	106	45	73	30
1901	48	112	41	75	28	42	105	44	74	28
1902	48	112	40	70	29	42	108	45	72	30
1903	47	114	41	76	28	42	109	44	71	30
Means	47	112	40	75	26	44	109	45	72	28

George E. Hunt, Chief Clerk Forecast Division.

RIVER AND FLOOD SERVICE.

The year 1903 was remarkable both for its unprecedented number of floods as well as for the extreme severity of many of them. There were floods of pronounced character in every month of the year except December. Detailed accounts of these floods will be found in the Weather Reviews for the appropriate months, except those of the great spring floods in the Mississippi watershed, which will shortly appear in a separate publication.

For all the floods the usual warnings were issued and the reputation of the River and Flood Service for promptness and accuracy was well maintained. For the great floods in the valleys of the Mississippi and Missouri the warnings, although issued from four days to four weeks in advance, were precise and of astonishing accuracy, both as to dates and stages, and they were the means of saving many lives and an immense amount of property that would otherwise have been lost.

During the year the New York and Texas river districts were greatly improved by the establishment of a considerable number of new stations. The district of Philadelphia was created, with territory comprising the watersheds of the Delaware and Passaic rivers. New stations were established as follows:

Hudson River.
Castleton, N. Y.
Cohoes, N. Y.
Corinth, N. Y.
Glens Falls, N. Y.
Mechanicsville, N. Y.
Stuyvesant, N. Y.
Troy, N. Y.

Passaic River.
Chatham, N. J.

Ramapo River.
Mahwah, N. J.

Sabine River.
Logansport, La.
Orange, Tex.

Mohawk River.
Fort Hunter, N. Y.
Little Falls, N. Y.
Schenectady, N. Y.
Utica, N. Y.

Trinity River.
Dallas, Tex.
Riverside, Tex.
Liberty, Tex.

Brazos River.
Hempstead, Tex.

Pompton River.
Pompton Plains, N. J.

Rockaway River.
Old Boonton, N. J.

Hoosick River.
Hoosick Falls, N. Y.
Schagticoke, N. Y.

Neches River.
Rockland, Tex.
Beaumont, Tex.

Colorado River.
Ballinger, Tex.
Austin, Tex.
Columbus, Tex.

The highest and lowest stages, together with the annual ranges at 151 selected stations are given in Table VII.—*H. C. Frankenfield, District Forecaster.*

REPORT OF THE CHIEF OF THE WEATHER BUREAU FOR THE FISCAL YEAR ENDING JUNE 30, 1903.

Dated August 11, 1903.

I have the honor to submit a report of the operations of the Weather Bureau during the fiscal year that ended June 30, 1903.

FORECAST DIVISION.

PRACTICAL VALUE OF FORECASTS AND WARNINGS.

The North Atlantic and West Indian forecast and storm-warning service was continued in successful operation during the year. Forecasts, for the first three days out, for the use of steamers bound for European ports were issued daily at 8 a. m. and 8 p. m., and the American and European shipping interests were notified of the character and probable course of the more severe storms that were passing eastward from the American coast.

No storms of hurricane strength occurred in the West Indies.

From October 31 to November 5, 1902, a storm that developed marked intensity over the Atlantic Ocean moved northeastward from the Caribbean Sea to the British Isles. Warnings were cabled well in advance of the storm to San Juan, Porto Rico, to Havana, Cuba, and to Weather Bureau stations on the coast from New Orleans, La., to Boston, Mass., to the observatory at Horta, Fayal, Azores, and to Lloyd's, London.

One of the most important storms of the year appeared on October 6, 1902, in the Gulf of Campeche, moved thence to the middle Gulf coast of the United States by the 10th, reached a position off the south New England coast by the morning of the 12th, and advanced over the Atlantic Ocean to a point near the north coast of Scotland by the 16th. Ample and timely warnings were issued to United States Gulf and Atlantic ports regarding the character and course of this storm.

During the late fall and winter months North Atlantic shipping interests were frequently advised regarding the approach and progress of the exceptionally severe storms of those seasons.

The first general frost of the season extended from the Northwestern States over the Lake region and central valleys, and as far south as Arkansas and northern parts of Mississippi, Alabama, and Georgia, from September 11 to 14, 1902. Timely warnings permitted protective measures in the districts visited by the frost of this period.

The first important cold wave of the season swept southward and eastward from the British Northwest Territory over the interior of the country from November 26 to 28, 1902, carrying the line of freezing temperature almost to the coast line of the Gulf of Mexico. Timely warnings were given to all interests that were subject to damage or loss by frost and cold.

The following comment was made by the New Orleans Times-Democrat of November 28, 1902, on the warnings issued for the Gulf district, the only section east of the Pacific coast States in which agricultural products were endangered by frost:

> The warnings sent out Wednesday morning were timely for all parts of this extensive district. Freezing weather occurred over Arkansas, Oklahoma, and northwest Texas. Heavy frosts occurred over the interior of Texas, and frost occurred generally over southern Texas and all of Louisiana. Frost was in evidence in New Orleans, and on the outskirts was quite heavy. The warnings of these severe conditions were issued by the Weather Bureau well in advance, and all business interests were prepared for the frosts and freezing.

The following is an extract from the Galveston (Tex.) News of December 4, 1902, with regard to the cold wave warnings of the 3d:

> Last winter the Weather Bureau saved many thousand dollars to the farmers and truck growers of south Texas by timely warnings of heavy freezes, and yesterday morning when the warnings were telegraphed and telephoned to points of interest no time was lost in getting the tender vegetation under cover. The Weather Bureau's notice was practically two days in advance, because the coldest period is expected to-night and early Friday morning. When Sugarland was communicated with the sugar mills were shut down at once and all hands took to the "tall cane fields," to use a common saying. It was reported that several hundred men were in the field cutting sugar cane and windrowing it an hour after the weather bulletin was received. The army of cutters was being rapidly reënforced, and it is expected that several hundred acres of cane will have been cut and stretched on the ground by to-night. A heavy freeze with the cane standing would play havoc and would mean the loss of perhaps thousands of dollars.

The following is an editorial from The Sugar Planters' Journal, New Orleans, La., of December 20, 1902:

> An evidence of the esteem in which the forecasts issued by the United States Weather Bureau at New Orleans are held was shown by the sugar planters all over the State by their windrowing thousands of acres of cane on receiving warning of the late cold snap, when the temperature fell as low as the freezing point, and in some places even lower.
>
> This faith in the prognostications of the "weather man" was largely brought about by the accurate forecast of the destructive freeze of last December, when the loss to the sugar industry of Louisiana figured, perhaps, upward of several millions of dollars. The exact loss by that terrible freeze will never be known. Had more planters windrowed promptly upon receiving warning last year from the Weather Bureau, the loss would have been greatly curtailed. The accuracy of the forecasts as now issued to the sugar planter has had much to do with the growing belief in the efficacy and wisdom of windrowing cane when a cold snap is predicted as about to swoop down on us. Fortunately, these warnings are generally issued some twenty-four or thirty-six hours ahead of the freeze, thereby allowing of a considerable amount of cane being placed safe in the windrow before its advent. It is considered by many, though, as wisest not to run too great a risk of being caught with a large area of cane in the field, and we find numbers of planters disposed to windrow about the middle of December, freeze or no freeze, provided they have sufficient cane to put the end of the campaign to as late as the middle of January.

The Tampa (Fla.) Herald, of December 27, 1902, remarked as follows regarding the warnings:

> "Heavy and damaging frost to-night" was the brief warning sent out over this section of the State yesterday by the local weather observer, but the warning, despite its brevity, was effective and doubtless saved thousands of dollars to the planters, especially those who own large "pineries," as the cold wave that struck the State was sufficient to greatly injure the "pines."

Mr. W. W. Fisher, president of the United Telephone Company, Bellefontaine, Ohio, under date of December 26, 1902, addressed the following letter to Mr. C. L. Lane, Weather Bureau displayman at Bellefontaine:

> Our telephone company desires to express in writing its appreciation of the cold-wave warning given by you to our superintendent on Wednesday last. We have 50 stations in our system, which extends throughout this and adjoining counties, and this news was immediately telephoned to each station with instructions to circulate the information there. In our system are a great many farmer subscribers, and this news was given to each farmer. We take pleasure in telling you that it was appreciated a great deal more than can be expressed here. We shall be pleased indeed to communicate to our patrons throughout our system any like information that comes to you in your position as voluntary observer of the United States Weather Bureau in our city, and we shall be glad to render you any assistance, at any time, within our power.

A notable feature of the weather of February, 1903, was that while a rapid succession of severe storms continued over the United States, the Atlantic, and northern Europe, the barometric pressure continued abnormally high over southern, and more especially southwestern Europe. From the 23d, when the center of the last American storm of the month reached the region north of Scotland, until the 28th, barometric pressures were low over southwestern Europe, and the center of a barometric depression of exceptional strength remained almost stationary north of the British Isles. The steep barometric gradient of this apparently stationary disturbance extended over the Atlantic almost to the American coast, and caused, during the last five or six days of the month, a con-

tinuation of violent gales from Newfoundland to the western European coast.

The first important storm of February occupied Nevada on the morning of the 1st, and reached the Gulf of St. Lawrence on the 5th. The heavy rains of the 3d, 4th, and 5th, accompanied by thawing, resulted in floods in the Allegheny and Monongahela rivers and tributaries. All interests about the headwaters of the Ohio likely to be affected by high water were kept informed by day and night of the stage of the rivers, and advices and warnings with regard to anticipated stages were issued hourly by the Pittsburg office of the Weather Bureau. On the 4th that office advised the public to prepare for high water, and predicted a stage of 24 feet on the gage at Pittsburg by the 5th. A stage of 24 feet was reached at noon on the 5th. On the morning of the 5th, when the western storm referred to was central over the Canadian maritime provinces, the following message was cabled to Lloyd's London:

> Severe storm will move eastward from Newfoundland to-day.

This storm reached a position north of the British Isles on the 10th, and by the morning of the 11th had passed over the northern portion of the Scandinavian Peninsula, with central barometric pressure about 28.40 inches.

The second storm of the month appeared on the 6th over New Mexico, to which position it probably advanced from the extreme southern California coast. Moving rapidly eastward this disturbance reached the middle Gulf coast on the morning of the 7th, passed northeastward to Lake Erie by the morning of the 8th, and reached Nova Scotia by the morning of the 9th, with rapidly increasing strength. On the morning of the 7th the following message was telegraphed from Washington to Weather Bureau stations in northern Ohio, western and northern Pennsylvania, and New York:

> Heavy snow indicated for to-night in northern Ohio, western Pennsylvania, western and northern New York.

Warning of heavy snow in northern Illinois and northern Indiana was sent from the Weather Bureau office at Chicago.

The snowfall of the 8th was particularly heavy in the central districts of New York, where railroad trains were delayed.

In connection with the cold wave of February 16 and 17, 1903, the Picayune, of New Orleans, on February 18, 1903, said:

> The severest weather of the winter throughout the Southwest prevailed yesterday morning. Owing to the forecaster's timely notice and warning to planting interests, sugar, truck, and orange growers having been forewarned in ample time, there were taken the proper precautions for the freeze and severe injury was averted. This forecast having been implicity believed by the agriculturist of the district, who had occasion last year to rely on Dr. Cline's accurate prediction, saved them many hundreds of thousands of dollars. When it is considered that such low temperatures do not occur in February more than once in eight or ten years, the successful forecasting thereof, in every instance of their occurrence, speaks much for the skill and efficiency of the Weather Bureau forecaster.

The following letter, dated February 21, 1903, was received by the Weather Bureau observer at San Antonio, Tex., from the president of the San Jose Truck Farm Company:

> The daily weather forecasts and particularly the cold-wave warnings of the recent cold snap, have been of inestimable value to us. It was only through careful attention to the forecasts from the Weather Bureau and promptly acting on the warnings that we have managed to bring through, without loss of a plant, our crop of 35 acres of tomatoes.

Gales of unusual severity prevailed on the North Atlantic coast of the United States during February 16 and 17, while in New England snow fell to the depth of 15 to 20 inches.

The Boston Globe of February 18 commented as follows regarding this storm:

> The biggest storm that Boston has seen for at least five years ceased yesterday, although its effects will be felt for several days yet. The storm was heralded by the Weather Bureau Sunday night. This gave sea captains more than eighteen hours notice and doubtless saved many vessels and lives.

The other Boston papers also made favorable mention of the storm warnings and forecasts.

The unpreceded floods in the lower Mississippi Valley in the spring of 1903 and the disastrous floods of May and June in the lower Mississippi and upper Mississippi valleys are discussed under the heading "Rivers and floods."

The quotations from the public press made in this report are but a few of the many favorable comments that reach this office. They are produced as impartial testimony to the high average verification of the important warnings of the Bureau and as unofficial evidence that the expenditure of one and a quarter million of dollars brings an adequate return to the commerce and industries of the country.

WEATHER MAPS.

The Weather Bureau issues each morning, excepting Sundays and holidays, about 25,000 maps that present graphically and by text and tables the weather conditions throughout the United States and Canada at 8 a. m., seventy-fifth meridian time. About 50 per cent of the maps are prepared at 23 of the larger stations of the Bureau by what is known as the chalk-plate process; the others are prepared at 71 of the less important stations by the milliograph, or wax-stencil process. All of the maps issued at stations are about 11 by 16 inches in size. The chalk-plate process of map making has proved satisfactory. By this process the mechanical part of map making can be expeditiously performed, and an unlimited number of maps can be issued. The milliograph process, while fairly satisfactory as regards the character of the work that can be performed, admits only of a small edition of maps, and is, therefore, unsuited to the requirements of large stations.

Experimental work in preparing chalk-plate maps of a larger size than those now issued at the more important stations has been conducted with a view of meeting an increasing demand from all sections of the country for maps that contain more complete weather data than can be published on the small maps now issued. The result of this work has been a practical demonstration of the feasibility of making maps about 22 by 16 inches in size (corresponding in size and make-up to the map issued at the central office at Washington) that will contain reports from all Weather Bureau stations, and also present graphically by symbols, lines, and shadings the wind and weather, barometric pressure, temperature, and rainfall throughout the entire region of observation.

The demand upon the Weather Bureau for maps of this character comes from commercial, agricultural, marine, and other interests; from educational institutions, and the general public. It can be met by equipping 20 of the more important stations of the Bureau with outfits for issuing the large chalk-plate maps, and transferring the present chalk-plate equipments to smaller stations, there to replace the milliograph process.

The approximate cost of equipping 20 stations for the issue of large chalk-plate maps, and 30 stations with the small chalk-plate map, including printing material and presses, stereotyping outfits, rent, power, and pay of printers, is $110,000, of which $40,000 is for assistance.

As the weather maps afford the only effective means possessed by the Weather Bureau for promptly placing before the public its daily observations and summaries, the improvement and extension of the maps along the lines indicated is urgently recommended. To carry out during the next fiscal year one-half of the plan outlined above it is recommended that $35,000 be added to the appropriation for "general expenses" outside of Washington, and $20,000 to the appropriation for salaries.

SCIENCE AND RESEARCH.

BAROMETRY.

The result of Prof. Frank H. Bigelow's discussion of the barometry observations that were made during the years from 1871 to 1900 have been incorporated in the Report of the

Chief of the Weather Bureau, 1900–1901, Vol. II, "The Barometry of the United States, Canada, and the West Indies." The data contained therein have been made the standard for the Weather Bureau, and the portions pertaining to the several stations have been put in operation, so that the barometry system has been made as efficient as possible in conformity with the best scientific models.

The adopted station elevations will be used as points of reference by local and general surveys; the normals of pressure, temperature, and vapor tension will be valuable in all meteorological and climatological studies; the variations of the pressure with the months, and from year to year, will be used in studying the effects of solar radiation upon weather conditions generally, and especially in laying a basis for seasonal forecasts.

The reductions of pressure have been made by suitable tables from the stations to the sea-level plane, and the synchronous isobars are used in constructing the daily weather maps. Besides this reduction to sea level, reductions of pressure to the 3500-foot plane have been made, which is at the average height of the plateau stations, and also to the 10,000-foot plane, which is located in the upper part of the ordinary cyclones and anticyclones. Daily reports of the pressures on these planes have been received by mail from the outlying stations in the United States and Canada, and these mail reports are being used in forming charts on the higher levels, whereby the structure of storms can be suitably studied for the first time in the history of meteorology.

This preliminary study will be continued for one year before rendering a report on the value of these high-level charts in practical forecasting. At present the indications are that they will be more efficient than was anticipated, and they certainly open a new field of investigation of the utmost importance in furthering our knowledge of the circulation of the atmosphere. Professor Bigelow believes that they have for the first time shown us positively what is the true structure of storms, and that they point unmistakably to a theory which will supersede those heretofore published in meteorological literature. It should be noted that three independent researches have converged upon the same result and that they mutually confirm one another, namely:

(1) The average circulation as derived from the auxiliary cloud maps used in the forecast division.

(2) The theodolite and nephoscope observations made by the Weather Bureau in 1896–97.

(3) The isobars constructed by the barometric reductions just mentioned.

These show that the general circulation and the local circulation merge into one another and form the observed cyclones and anticyclones; that the source of energy for the general circulation is the sun's radiation in the Tropics, and for the local disturbance the counterflow and underflow of low-level currents of different temperatures between the tropical and the polar zones. This result excludes three well-known theories: (1) The local overheating of the surface strata; (2) the latent heat of the condensation of the aqueous vapor; and, (3) the eddies attributed to difference of velocities of adjacent strata. Storms are actually more complicated than was supposed, and it will require some careful work to finish up the subject, but the prospect of obtaining a satisfactory outcome is now promising.

Besides this work on the mechanics of the local cyclones, the nephoscope observations made in the West Indies in the years 1899–1903 are being discussed by Professor Bigelow, who hopes to derive therefrom more definite results regarding the circulation of the air in the Tropics and in the formation of the trade winds.

The data are being collected for a report on temperatures and vapor tensions, with the view of ultimately constructing high-level isotherms and vapor lines in connection with the above-mentioned isobars.

This work has been the special field of Professor Bigelow. It is all highly important to the science of meteorology.

METEOROLOGICAL INVESTIGATIONS.

The Weather Bureau has also been carrying on for some years an investigation into the fundamental problems as to the true causes of the weather conditions in the United States, the ultimate purpose of which is to improve the forecasts issued for a day or two in advance, and, if possible, to discover some basis for a scientific forecast of the seasonal variations from year to year. Sufficient progress has been made in practical methods to justify a summary of the work already done, and especially to point out the steps which should be taken to secure to meteorology a positive advance as a science and as an art of commercial utility. The methods at present employed in making up the daily forecasts are substantially the same that were devised at the time the Government service was established in 1870. Every effort has been made to bring the system to perfection, and much labor has been devoted to the study of the sea-level charts upon which it is based in order to secure the best results in forecasting that are possible with that kind of data, namely, the isobars, isotherms, wind velocities and directions, and precipitation areas, as published on the daily weather maps. Yet it has been impracticable to avoid a certain class of errors in reading these charts, though a sufficiently high average of correct forecasting has been maintained to justify the expense of the service; but it is apparent that much labor in research is justifiable where there is a fair promise of an ultimate improvement in successful forecasting. The mistakes in judging the immediate development of the sea-level maps consist usually in an error as to (1) the direction of the storm track, (2) the rapidity of its onward march, (3) the intensity of its action, and (4) the location of the accompanying rainfall areas. Therefore any improvement of the system of forecasting must have an especial regard to these four points.

STUDY OF CYCLONES AND ITS VALUE FOR DAILY FORECASTS.

Before mentioning the results of recent researches it is proper to enumerate the most important theories regarding the circulation of the atmosphere generally and locally in order to contrast them with the new theory.

General circulation.—Professor Ferrel's theory was practically undisputed by meteorologists until the cloud observations made by the Weather Bureau in 1896–97, published in the Report of the Chief of the Weather Bureau for 1898–99, indicated that it must be greatly modified to match the true circulation of the atmosphere. The European and Asiatic observations made at the same time, the results having been published by Hildebrandsson for the international committee in 1903, are in agreement on this point with those of the Weather Bureau. Ferrel reasoned as follows: The sun's radiation heats the air in the tropical zones, causes it to rise upward and then to flow poleward in the high strata, and return to the Tropics in the low strata near the surface. The rotation of the earth, whose atmosphere is thus heated, causes an eastward rapid drift in zones north of 30° latitude and a westward drift in the tropical zones.

Now, as a matter of fact, our cloud observations showed for the United States that in the upper strata there is no such northward current as Ferrel assumed to exist. The flow from the Tropics to the poles is not in the higher levels, but in the lower levels up to 3 or 4 miles elevation, and not above that height. There are strong currents of warm air which flow from the Tropics into the temperate zones at low levels, and there they meet the cold currents flowing southward from the polar regions. These counterflowing currents, which at the same time underflow the eastward drift in the upper strata, possess the thermal energy necessary to generate cyclones and

anticyclones, and the natural function of these gyrating masses of air of different temperatures is to bring back to an equilibrium the thermal state of the atmosphere, which is being continually disturbed by the sun's radiation falling upon the tropical zones.

Local circulation.—There are three distinct theories which have been strongly advocated by students to explain the origin of cyclones and anticyclones: (1) The Ferrel vertical convection theory, (2) the German vertical convection theory, and (3) the dynamic eddy theory. It is not practicable to describe these in detail, but the principal ideas are as follows:

(1) Ferrel conceived his local cyclone as similar to his general cyclone, and illustrated it by heating at the center of the lower surface a mass of water contained in a cylindrical vessel, turning it at the same time bodily about its vertical axis. This makes the water flow in certain *closed* curves, since it is the *same* mass of water in motion. We now know from recent observations that the air simply flows once through a cyclone, and that new masses of air are constantly involved, so that Ferrel's idea can not be true. For a central source of heat Ferrel accepted Espy's view, that the latent heat of condensation due to rainfall is the source of the vertical current. There are, however, many fully formed cyclones that are practically dry, so that the latent heat can not be more than a secondary source of energy in the production of storms, though it may intensify a given cyclone.

(2) The German vortex is much nearer to the facts of nature, because it is not limited to a fixed mass of air, but allows new air to stream through it. In this case we have a central part with a vertical velocity surrounded by currents flowing only in horizontal directions, and suddenly lifted on reaching the central core. In this vortex the central vertical velocity increases in proportion to the height, and it would become enormous in the upper strata. Recently discovered facts do not sustain these ideas very well, and they must be much modified. The German vortex theory, as well as the Ferrel vortex, has relied upon the latent heat of condensation for the central rising current, but there are several intractable difficulties which stand in the way of accepting either of these theories. Indeed, so strong have these objections appeared to some students that they have abandoned the convection theories depending on thermal energy and have taken up the purely mechanical or dynamic theory of eddies.

(3) The eddy theory considers the cyclones as simply whirlpools produced by currents flowing past each other at different velocities, especially in the temperate zones, much as eddies are formed in a rapid stream of water. It is only necessary to note that cyclones form frequently and numerously in the Southern States, that is, in the midst of the high pressure belt, where there is no rapid motion east or west of any kind; that the adjacent strata in the temperate zones do not have sufficient differences of eastward velocity to stir up genuine eddies on a large scale; and that over Asia and the Pacific Ocean, where similar eastward velocities prevail, there are practically no cyclones as compared with the number in North America, the North Atlantic Ocean, and Europe.

Professor Bigelow has found the conditions of this complex problem generally satisfied by admitting the counterflow and underflow of currents of different temperatures at low elevations, such as have been deduced from our observations on the flow of the atmosphere, and from our new barometric reductions to the 3500-foot plane and the 10,000-foot plane. It will be necessary to give more detailed attention to these results, as yet unpublished, except for one paper in the Monthly Weather Review in February, 1903. The importance of arriving at the correct structure of cyclones, or the configuration of the curves through which the air circulates in them, is so great that it has been discussed in three independent ways, which mutually sustain one another by coming to the same result.

(*a*) The first method consisted in taking the cloud maps used as auxiliaries in forecasting, selecting 40 or 50 maps in a series of years having the same region for the storm center, as the Lake region, and computing the resultant motions in all the minor areas of the cyclone. There was published in the cloud report a series of such resultant cyclones for the sea level, the cumulus cloud level, 1 to 2 miles high, and for the cirrus cloud level, 5 to 7 miles high.

(*b*) To carry out the second method, theodolite observations were made at Washington for one year, May, 1896, to May, 1897, and nephoscope observations were conducted simultaneously at 14 stations scattered quite regularly to the east of the Rocky Mountains, upon the cloud motions in nine different cloud levels from the surface of the ground up to the cirrus level, and in each of these the actual velocity was measured or found by computations. From these data a structure was obtained for the cyclone in agreement with that of the first method.

(*c*) Finally, the barometry observations taken in the United States since 1873 have been reduced to a homogeneous system, and all the necessary corrections have been applied to make the series from January 1 of that year up to the present time strictly comparable. From these data, and with the help of the temperature gradients found from the observations made during the kite ascensions of 1898 in the Mississippi Valley, together with the available European balloon ascensions, it was possible to construct normal maps of the pressure, temperature, and vapor tension on the sea-level plane, the 3500-foot plane, and the 10,000-foot plane, for the twelve months of the year.

Also, reduction tables were constructed to facilitate finding the pressure daily on these three planes at about 150 stations in the United States. The sea-level reductions have been used since January 1, 1902, in making the weather maps employed in forecast work and issued to the public at several centers. Since December 1, 1902, the reduced pressures on the 3500-foot plane and the 10,000-foot plane have been sent to Washington on postal cards, whereby the maps on the higher planes are drawn for comparison with the sea-level charts. At the present writing Professor Bigelow has examined these maps for six months, with the following general conclusions:

(1) The high-level isobars give precisely the same configurations for the structure of cyclones and anticyclones as were obtained from the cloud charts and the direct instrumental observations, so that the barometry report, in the Report of the Chief of the Weather Bureau, 1900–1901, confirms the results of the cloud report.

(2) The great advantage pertaining to this isobaric system is that the details are given on the upper levels in great abundance and variety, and they serve for studying these meteorological problems in many different aspects. It will be possible only by preparing a special report on the subject, which is now in process of construction, to give any idea of the new information contained in these high-level charts, and we hope to issue this report within the coming year.

(3) It may be stated in this place that the cyclones are formed by currents flowing into the temperate zones from either side in the low levels, that is, a mile or two above the ground, where, by the intermixing and the change of elevation which is induced by their difference of temperature, they cause the gyrations usually observed at the surface in the low and high pressure areas. If a warm current underflows a relatively cold current, the lower air rises, cools its vapor contents, and precipitates the same over wide areas. Precipitation is due to the lifting of the air in part by dynamic vortices where the isobars are closed curves and in part by underflowing warm, moist sheets of air, which are not vortices. There are many examples of the fact that the warm and moist southerly currents of the 3500-foot level, underflow the cold currents drifting

eastward at the 10,000-foot level and precipitate their contents of moisture over large areas. These upper-level maps, at least in the six months from November to April, inclusive, most efficiently supplement the rainfall forecast indicated by the usual sea-level maps, and in many instances they clearly show the rain area for the next thirty-six hours, while the sea-level weather map fails to give such information with the necessary distinctness. This conclusion is very promising, as indicating a probable improvement in the rain forecasts in the winter months. In the summer the system is different from that of the winter, and it is not possible at present to make any statement regarding the efficiency in the warm season.

(4) It happens that on the upper levels the direction of the storm track may often be shown by the trend of the isobars on the 10,000-foot plane. If these slope to the northeast the cyclone usually moves in that direction; if to the southeast it still follows them. Thus, instead of conjecturing in which of two possible paths the storm center will advance, it is practicable to select the one it usually will follow by reference to the upper isobars. Furthermore, the density of the isobars on the 10,000-foot plane, that is, the closeness with which they are packed together, is a very strong indication of the relative velocity with which the cyclone will move. If they are close together it will advance rapidly; if they are wide apart or straggling it will move slowly. The difference in velocity between the cyclones of January and May, for example, is a good illustration of this law, and it is likely that a suitable study of this subject will enable the forecaster to judge much more accurately of the storm's progress than has been possible from the sea-level charts alone.

(5) The penetrating power of cyclones and anticyclones into the higher levels is distinctly shown by the changing configuration of the isobars on the three successive planes. The number of closed isobars, within which a purely vortex motion with a vertical component can alone exist, diminishes from the surface upward; the closed isobars change into sinuous curves before they ultimately disappear in the swiftly moving eastward drift of the high levels. It has been shown that in the case of hurricanes the penetration reaches powerfully to the cirrus level, 6 miles from the surface, and with precisely the same typical configuration for the circulation. There are many other interesting features which are contained in this series of charts, but it will be proper to reserve them for further study before expressing conclusions regarding them. Enough has already been discovered to inspire a feeling of confidence that the high-level charts will efficiently supplement the sea-level charts, and in some cases supersede them in forecasting usefulness. It is possible to telegraph the data needed for constructing them by adding one word to the forecast code, such as a word of the barometer-temperature type, and a single clerk can draw the two sets of upper isobars while the usual sea-level charts are being made. It will require considerable study on the part of the Forecast Division to thoroughly digest the new material and overcome a feeling of strangeness. Thus, in cold waves we see on the sea-level plane a very high pressure, but on the 10,000-foot plane a distinct low pressure over it. The new charts also will dispel many erroneous conceptions now held by the public regarding the true theory of storms.

THE PROBLEM OF SEASONAL FORECASTS FOR A YEAR.

It is a very difficult piece of science that is involved in the attempt to place the forecasts of the seasons for a year in advance upon a reliable basis, because it will be necessary to take account of several interrelated processes in nature, which depend upon the circulation of the atmosphere of the sun and of the earth. Professor Bigelow states that:

"The science of meteorology is not to be confined to the atmosphere of the earth; because the changes in the action of the atmosphere of the sun precede the variations in the earth's air, which finally culminate in a certain type of season. Thus, wet and dry seasons, warm and cold summers and winters, and all the other climatic differences first depend upon the persistence of special high and low areas of pressure in one locality or another; these go back to the circulation of the great currents in the atmosphere, which seem to surge back and forth from one side of the earth to the other, or from the oceans to the continents; finally, these currents are probably due to the solar radiation, which itself changes with the output of energy from the interior of the sun. Thus, meteorology is really a very closely allied but difficult branch of solar physics, and it ought to be studied with the aid of a fully equipped observatory devoted especially to such researches. On the sun we count up the number of hydrogen flames or prominences seen on the edge of the disk from day to day, and, from a discussion of the thirty years' record in hand, they are known to vary strongly from year to year. Similarly, the faculæ and spots have their fluctuations in synchronous cycles, and these have been studied for many years. Furthermore, the sun emits energy in the form of radiant light and invisible heat, and by means of suitable spectrum observations the variable amount of this light, and especially the invisible heat, can be registered from day to day and from year to year. The result of these records is to indicate that the sun is in fact a great, variable star, and that terrestrial weather changes in close synchronism with it. There is yet another register of the energy emitted by the sun to be found in the variations of the earth's electrical and magnetic fields, which is perhaps the most sensitive of all, and certainly the most accessible to our measures. The newly discovered action of ions in the atmospheres of the sun and the earth, respectively, which are now believed to be the basis of the electrical and magnetic manifestations, is affording much information upon this obscure subject, and is full of promise in practical investigations. Langley has announced that the invisible radiant heat energy, as measured in his bolographs, varies from season to season and from year to year. The passage of an eclipse shadow through the atmosphere changes the atmospheric magnetism and electricity in the same way that day and night modify them—by cutting out the sun's rays. In short, the entire field of cosmical processes forms a complex problem which especially concerns the meteorologist, and by him should be studied out for the benefit of mankind, whose life and happiness depend so largely upon the weather."

MOUNT WEATHER RESEARCH OBSERVATORY.

The Weather Bureau is so far convinced of the importance of finding out the laws of this cosmical physics, by which alone the problem can be conclusively solved, that it has been thought proper to found a research observatory at Mount Weather, on the crest of the Blue Ridge Mountains, about 6 miles from Bluemont, Va., and equip it suitably for these investigations. Professor Bigelow has recently been placed in charge of supervising the plans for its construction and development upon the best modern principles. It is evident that such an institution, having its beginning in the early years of the twentieth century, will have an increased usefulness as the years go by, if it is organized according to the demands of the best science. It will require fine instruments and able students if it is to command the respect of the scientific world. The subject of solar physics has already grown to such proportions that the British Association for the Advancement of Science has set off a solar physics section from astronomy and mathematics; the solar physics observatory at South Kensington, under the able directorship of Sir Norman Lockyer, is putting forth valuable results; the solar observations by the Italians for the past thirty years have become invaluable as a basis for these studies; the observatory at Kalocsa, Hungary, and that at Zurich are known to all students for their important publications. Less directly, sev-

eral of the great astronomical observatories are deriving some of their most valuable discoveries in astrophysics, which is simply another name for stellar meteorology. Thus, Potsdam, Paris, Lick, Yerkes, Harvard, and other institutions are working zealously along these lines and filling out the realm of human knowledge in a fashion undreamed of a generation ago. It may be asked why, with all this wealth of material being secured in other places, it should be important for the Weather Bureau to enter upon these studies as well. The answer is simple. These observatories, for one thing, specialize along certain lines, and it is evident that there should be at least one institution in the United States where these results are brought together and studied side by side, so that their combined result at a given time can be worked out harmoniously and correlated with the prevailing weather conditions. Furthermore, the publications of these several observatories are issued from the press as much as two to four years after the observations are actually made, so that it is obvious that these late reports can have little value in practical forecasting. We have no intention to enter upon the advanced research problems which rightly belong to specialists, but rather to adapt to the uses of the meteorologist and the forecaster such portions of the well-known types of observatories as seem to be practicable for the immediate uses of the Weather Bureau.

Specifically, the plan in mind contemplates the development of an observatory as indicated in the following statement:

(1) An observatory building is in process of erection at Mount Weather, which is well adapted as a school of instruction and for making observations of the ordinary kind with the common meteorological instruments, barometers, thermometers, wind and rain gages, nephoscopes, theodolites, and actinometers. The first floor is for administration, the second for living quarters, the third for laboratories, and the roof for observing.

(2) Plans are being prepared for a plant adapted to generate large quantities of hydrogen, for balloon ascensions, including a shop for the construction of balloons and kites. The ascensions will be limited to about 4 miles in height, our immediate purpose being to measure the temperatures and thermal gradients, which will enable us to construct daily isothermal charts on the two upper planes already described, so as to provide isotherms as well as isobars on the high levels. It is proposed to make a complete series of ascensions first at Mount Weather, and afterwards in different portions of the United States, in order to observe the temperature conditions in all classes of cyclones and anticyclones. We may attempt some high ascensions, up to 10 or 12 miles from the ground, when our experience and other conditions warrant, but, since storm movements are practically limited to the strata within 4 miles of the ground, the first group of ascensions will be to moderate elevations.

(3) It seems important to install a high-grade bolometer for measuring the invisible solar radiation, which is thought by some students to be largely responsible for the actual temperature of the upper atmosphere. Also, a first-class spectroheliograph is required for keeping a record of the solar prominences, faculæ, and spots prevailing at the time of making our weather forecasts. These two instruments are the essentials of an efficient solar physics observatory, and would require the services of an able student of physics to bring out the best results and discuss them efficiently in suitable reports.

(4) These records should evidently be supplemented by an observatory equipped with modern instruments for observations in atmospheric electricity and in magnetism, and we note that a number of valuable new instruments have been invented in recent years which we can use. The special subject of this research is the behavior of ions in the atmosphere as forerunners of weather conditions.

Generally, the idea is to bring together for study under one direction the most valuable and practicable observations having a direct bearing on the higher meteorology, which is now engaging the attention of many able physicists and astronomers. In this field are found the best examples of physical and mathematical problems, because it is nature's great laboratory. The atmospheric conditions at Mount Weather are superb, the site being 1800 feet above the sea level, on a ridge overlooking the wide Shenandoah Valley to the west and the plains of Virginia to the east. An equipment at that place, such as is contemplated, will induce a great scientific activity and generate an intellectual atmosphere highly favorable to the best scholarship. The assistants in charge of the various lines of work will form a strong corps of teachers, who will instruct a new generation of men in the great problems of meteorology, which are destined to occupy the attention of mankind in an increasing ratio with the lapse of time. If the equipment be made up of the very best instruments and able students secured to use them, and especially if patience be manifested in allowing the data to accumulate and be studied in the proper way, an improvement in forecasting for America should be assured. This institution is to be planned for continuous work in the future, and it is not supposed that its effect on forecasting will be immediately manifest, because of the difficulty and complexity of the problems involved. One thing is certain, that the founding of such a research institution is the true scientific way to provide for the future, in assurance that the natural difficulties will finally yield to human persistency and intelligence.

TELEGRAPH DIVISION.

Our relations with the principal telegraph companies transacting the steadily increasing telegraph business of this Bureau have, in the main, continued satisfactory. Complaints of delays and other faults in the transmission or delivery of telegrams have, as a rule, received prompt attention and corrective action. Special acknowledgment in this direction is due to the local managers of the two principal telegraph companies in this city, whose unvarying zeal and courtesy have contributed much toward the prompt investigation of complaints and the application of corrective measures where called for.

The total mileage of telegraph and telephone lines controlled by this Bureau was increased from 367 miles, at the date of last report, to 421 miles, by the construction and equipment of the following new sections:

(1) From Pacific City (Fort Canby), Wash., to North Head, Wash., 2 miles; completed August 1, 1902. This section connects the observation and storm-warning display station at North Head with the general telegraph system, and its value may be judged by the following extract from an editorial in the Portland (Oreg.) Oregonian of November 11, 1902, viz:

> With the exception of the light-house service along the Oregon and Washington coasts, no greater aid to shipping bound for the Columbia River has ever been extended than by the recent establishment of a reporting station at North Head. * * * The work of the Weather Bureau in this direction has been of great benefit to the agricultural and shipping interests of this district, but no branch of the service has shown its value more effectively than has the reporting station at the mouth of the Columbia River.

Vessel and weather reports are now telephoned direct from North Head to Portland, Oreg., for distribution.

(2) Nine miles of submarine cable from Key West, Fla., to the office of the newly established vessel-reporting and storm-warning display station on Sand Key Island, Fla. This connection was completed on February 26, 1903, and serves the important purpose of reporting to the maritime exchanges at New Orleans and other points the passing of vessels to or from Gulf ports and the occurrence of any marine casualties in the vicinity; also for the display of storm warnings at critical seasons.

(3) A submarine cable from Point Reyes Light, Cal., to Southeast Farallon Island, Cal., 23½ miles in length, with about 3½

miles of land line. This cable was successfully laid and put into operation on April 14, 1903, for observation and vessel-reporting purposes, connecting at Point Reyes with the old line to San Francisco; but only twelve days later it was fouled by the anchor of the steamer *South Portland* and cut in two by the captain's orders, who claims such action to have been necessary to save his vessel. This occurred off Drake's Bay, about 1 mile from the cable landing at Point Reyes. The cable has since been recovered and repaired.

(4) A two-wire land line from Bluemont, Va., to the observatory now under construction on Mount Weather, Va., a distance of about 6 miles. This line was completed on May 8, 1903.

(5) Eight miles of submarine cable and 2 miles of land line from Glen Haven, Mich., to the newly established storm-warning display station on South Manitou Island, Lake Michigan. This work was done under the personal direction of Mr. J. H. Robinson, superintendent of telegraph, who also supervised the erection of a steel storm-warning tower on the island. The cable was laid on May 9, 1903, and the station put into operation a few days later.

In connection with the South Manitou Island line, it should be mentioned that the employees of the light-house and life-saving services and other residents are very desirous of having this Bureau extend its cable line from South Manitou to North Manitou Island. While on the ground, Mr. Robinson made inquiry as to the benefit such a line would be to lake navigation, and learned that it would be useful in reporting and conveying orders to vessels that seek the North Manitou Harbor, and that the island would also be a valuable point for the display of storm warnings. By utilizing the spare cable stored at Charlevoix the connection could be made and a steel tower erected on North Manitou for $2000 or less. It is, therefore, recommended that the next Congress be asked for an appropriation of $2000 for this purpose.

Telegraphic connection with Tatoosh Island, Wash., was reestablished during November, 1902, by means of a steel span wire, in lieu of the old submarine cable that failed in 1898; but the extraordinary difficulties encountered in the construction and maintenance of a land line to Cape Flattery, which for the past twenty years have rendered telegraphic communication with this important outpost exceedingly precarious in spite of our best efforts, call for different methods of meeting the urgent demands for regular, uninterrupted weather and vessel reports from Tatoosh Island. An all-cable line from Port Angeles to Tatoosh Island offers the only practical solution of the problem. This, together with a cable from Flavel, Oreg., to Fort Canby, Wash., which is necessary for the betterment of the North Head weather and vessel reporting service, calls for an appropriation of $90,000. It is recommended Congress be asked to allow $15,000 with which to lay the Flavel-Canby part next year.

An additional appropriation of $10,000 is recommended for the much-needed reconstruction of the important Hatteras line, including an extension of the same to Roanoke Island.

Action to equip the Point Reyes-San Francisco line with hard-drawn copper wire, in lieu of the old iron wire now in use, will be taken during the present year.

An attempt was made during last August to recover and repair the old Signal Service cable from Narragansett, R. I., to Block Island, which had been transferred to this Bureau. The cable, however, was found to be practically worthless for further use, and the attempt had to be abandoned. The Weather Bureau cable to Block Island, laid in 1886, became defective in November of 1902. In making repairs it was discovered that this cable also was in a very bad condition and liable to fail entirely at any time. Congress, therefore, granted an appropriation last winter for a new 3-conductor cable, which will be laid during the present summer.

The great demand for additional Weather Bureau reports from many important classes of industry renders it advisable to request an addition to the present appropriation for "general expenses" of $50,000, to be used in the distribution of weather observations, warnings, and forecasts by telegraph.

The total cash receipts of the Weather Bureau lines that are authorized to carry commercial (paid) business, amounted during the year to $5288.38, of which amount $2687.58 was for "this line" (U. S.) and $2600.80 for "other line" tolls.

RIVER AND FLOOD SERVICE.

The work of the river and flood service, owing to the recent numerous and disastrous floods, has of necessity been a very prominent feature of the year. Several of the floods were the greatest of which there is authentic record, and were remarkable both for their wide extent and destructive character. In no instance was the coming of a dangerous flood unheralded. The warnings were uniform, prompt, and timely, and in the main remarkably accurate. The forecasts of the great floods of March, April, and June, 1903, afford noteworthy examples of the efficiency to which the River and Flood Service has attained, and will be made the subject of more extended mention later. The following extract from an editorial in the New Orleans Times-Democrat of April 12, 1903, testifies to the value of the work:

> We have been placed this year under another obligation to the Weather Bureau for its high-water news and predictions. It has kept the people of the lower Mississippi well informed of what they may expect in the way of high water, and its predictions have been subsequently verified by the facts. * * *
>
> It has predicted within a fraction of a foot the height the river would reach at various points and been very close to the date of maximum high water. * * *
>
> The day that the high water would reach New Orleans was stated with remarkable accuracy, for it was between three and four weeks after this warning that the wave crest reached here.
>
> That the warning, like that of an approaching freeze, had a good effect, none can doubt. It let the levee boards, planters, and public generally know what to expect in the way of high water and warned them to prepare accordingly; and they did prepare, raising the levees to the height sufficient to withstand the flood which the Weather Bureau warned us was coming. In this way, therefore, it contributed not a little to the energetic and generally successful campaign against the flood carried on this year.

The importance of the river service to the transportation interests of the Ohio River has been dwelt upon at various times. It is only necessary now to say that upon the efficiency of the one largely depends the prosperity of the other, and that the Weather Bureau has contributed much to the latter by maintaining in its river forecasts a high degree of accuracy, both during flood and the almost equally important low-water periods. These remarks apply with equal force to the remaining river districts, where very successful work has been somewhat overshadowed by the floods in the three great interior rivers.

The best recommendation that can be given work of this character is a demand for the broadening of its field of operations and the extension of its benefits to localities not yet favored. Such demands have been constant and persistent, yet lack of the necessary funds has rendered it impossible to meet more than a small percentage of them. In several instances the limitations placed upon the work by lack of funds have seriously handicapped its efficiency and thereby caused loss of lives and property that might otherwise have been saved. The recent flood in the Kansas River was an unfortunate, yet none the less instructive, case. Had the Weather Bureau been able to maintain an adequate river service over this district it is practically certain that more accurate forecasts of the coming flood could have been issued and many lives and much valuable property saved as a result thereof.

It has been found to be practically impossible in recent years to obtain even moderately accurate estimates of the property saved through flood warnings. Formerly the warnings, owing

to their very general nature, did not command the attention that the later and more specific ones compel, and interests were easily centered upon any marked benefits. But in these days the many and diverse interests that are more or less concerned with river stages have come to look upon the river forecasts of the Weather Bureau, both daily and special, as a legitimate and necessary portion of their business, an always available, if not a tangible, asset. It is impossible to make a record in dollars and cents of the benefits derived. However, general estimates can be made.

The great floods of the year were those of the Red River in November and December, the Ohio and lower Mississippi in March and April, and the lower Missouri and upper Mississippi and their tributaries in May and June. The first overflowed a territory in southwestern Arkansas and northwestern Louisiana, approximating 200 square miles in extent, and the property loss amounted to over $500,000. This flood began about November 26 and continued throughout the following month. On November 23 the Central Office at Washington advised that "all necessary precautions should be taken for the removal of stock and property liable to be damaged by flood." These warnings were thereafter repeated daily, gradually becoming more specific as to time and height of the crest stage expected, until all danger had passed. The warnings were issued from seven to fourteen days in advance of the floods, and the crest stages in various localities were correctly forecast to within a small fraction of a foot.

Mr. H. Hawkins, secretary of the Shreveport (La.) Board of Trade, wrote as follows:

> The flood warnings sent out by the Weather Bureau before and during the overflow were so accurate and timely that all had ample time to protect themselves. In consequence of said warnings there was no loss of live stock and practically no loss of movable property. We have no data from which to compute the actual value of property threatened by the overflow, but it runs into the hundreds of thousands. Certainly the Weather Bureau did wonderful work.

This is but one of the many commendatory letters and press notices relative to this flood that were received.

The flood of March and April in the lower Mississippi River was the greatest in the recorded history of that section, and its culmination was awaited with feelings of deepest apprehension and concern. Although the aggregate volume of water was less than in the great flood of 1897, yet the extension of existing levees and the building of new ones had still more restricted the natural channels, and the outcome of the new conditions was difficult to forecast. The test of actual experience was necessary. Despite these difficulties the warnings of the Weather Bureau were characterized by an almost absolute accuracy, and were issued from four days to four weeks in advance. With stages of water higher than ever before known, and with the prevailing uncertainty as to the effects of the new levees, the maximum difference between the forecasted stages and those actually recorded was only *three-tenths of a foot*, that being at New Orleans, where four weeks' notice had been given of the coming flood crest. The forecasts, however, were conditioned upon the levees remaining intact, and had they not broken in a few places even this difference, slight though it was, would probably not have occurred. The following table shows in a concise manner the stages forecast and those actually reached:

Forecasts of lower Mississippi River flood and stages actually reached.

Stations.	Forecast stage.	Actual stage.
	Feet.	*Feet.*
Cairo	50.5 to 51	50.6
Memphis	40	40.1
Helena	51	51
Arkansas City	53	53
Greenville	49	49.1
Vicksburg	52	51.8
New Orleans	21	20.4 to 20.7

Owing to the timely issue and effective distribution of the flood warnings the actual losses, beyond the inconvenience and delay caused by the overflowing of plantation lands, were comparatively small. All portable property was removed to places of safety and every possible precaution taken to protect that which could not be moved.

The floods of late May and early June, 1903, in the upper Mississippi, the lower Missouri, and the Kansas rivers were by far the most destructive, and with the exception of that of 1844, the greatest ever experienced in these localities. The warnings for the upper Mississippi were equally as accurate as those for the previous flood in the lower river. Ample time was afforded to every one to make all preparations that might be necessary, and if some delayed until too late, their failure to act more promptly certainly can not be attributed to lack of emphatic and accurate warnings. At St Louis, on June 5, one week or more after the flood warnings were begun, a special warning was issued that in about four days a stage of water in the neighborhood of 38 feet might be expected, the gauge reading at that time being 33.5 feet. On June 10 the water reached the height of *exactly* 38 feet and then began to recede. The floods in the Kansas River and in the Missouri in the vicinity of Kansas City could be forecast only in a general way, owing to the fact that no river service was maintained on the Kansas River, it having heretofore been found impossible to obtain sufficient funds for that purpose. The warnings issued stated that serious floods were probable, higher than had occurred for twenty years or more, but no definite forecasts could be made on account of lack of information of any description from points above the threatened districts. Had the Weather Bureau possessed an adequate river service within the State of Kansas during the recent flood, there is not the slightest doubt that, while some lives might have been lost, others that were lost would have been saved by the warnings that could have been issued, and property to the value of hundreds of thousands of dollars rescued from the general ruin. It is strongly urged that Congress provide the necessary funds for the river service so greatly needed in Kansas and many other localities.

The demands for the extension of the River and Flood Service are utterly beyond the ability of the Bureau to supply. The majority of these demands are necessary for the well-being of the agricultural and commercial interests of the country, and the cost thereof would be comparatively insignificant. A new service should be at once inaugurated on the Kansas and its tributaries, on the Delaware, and in other localities, and additional stations supplied to many of the already existing districts. The telegraph service should also be extended in order that the daily reports, so necessary in many localities for accurate forecasting, may be furnished the various river centers.

The work of the service should also be broadened so as to embrace other and very necessary coordinate branches. The volume of water in the rivers corresponding to given stages in feet from the lowest water level to the highest flood plane should be measured. Information of this character affords a truer index of the real conditions than do the ordinary expressions in feet, which are at best the measured height of the water above arbitrarily assumed points, and are used chiefly because they are the most convenient vehicle for the conveyance of information to the general public. During recent years no connected series of discharge observations has been made in the large rivers of the country. An opportunity for doing a great service was lost through want of money during the spring floods of 1903, and it is hoped that another instance will not find us unprepared.

Another important field as yet imperfectly developed, but one of first importance to the student of river régime, is that of the connection of rain and snowfall with the varying stages of the rivers. The relations between the two are subject to

so many intricate and everchanging conditions of climate and topography that regular daily observations at a large number of places are absolutely essential if the best results are to be obtained. The winter snows in the mountain are often the controlling factors in our early spring floods, and if they are to be properly reported numerous stations of observation must be provided. Of equal importance are reports of heavy rainfalls along the headwaters of the various streams. For this work many special rainfall stations are necessary.

The work of the River and Flood Service during the past year speaks for itself. Its excellent work, while greatly handicapped by reason of enforced limitations, is but an indication of what can be done if proper facilities are provided. The value of property saved through the flood warnings of this year alone would more than provide for the needs of this service for a century to come, and I can not too strongly recommend that funds amply sufficient for the work be provided by Congress.

I am strongly of the opinion that the time has come when the River and Flood Service should be raised from its position as a part of a division and given the rank of a division, with such a complement of officials and clerks and such an increase in the funds allotted to its purposes as will enable it to still further perfect and extend the river and flood work so as to meet the needs of agriculture and commerce. The new division, if created, should, as is now the case, be closely affiliated with the Forecast Division, and the official in charge, in so far as the issuing of flood warnings is concerned, remain under the general supervision of the professor in charge of the Forecast Division. I, therefore, have the honor to recommend that Congress be asked to appropriate for one additional professor, at $3000; one clerk, at $1800; one clerk, at $1200; one clerk, at $1000, and one copyist, at $840. But $17,000 is now spent for the pay of special river and rainfall observers and for the building of river gages, and there are no measurements made of the sectional discharge of rivers. In order to extend the River and Flood Service, as hereinbefore outlined, I would also recommend that Congress be asked to increase the amount allowed for "general expenses" of the Weather Bureau outside of Washington by $30,000. This additional amount will enable the Weather Bureau to do a splendid service for the interior commerce of our country.

The plan recommended would give to the chief forecaster of the Bureau $3000, and the $2500 professorship now held by him would be given to chief of the new river and flood division, and one district forecaster at $2000 would be dispensed with. The officials referred to are men of high scientific attainments; they have seen many years of arduous service and study; neither of them has been engaged in the work for less than twenty years, and they are in the front rank of their profession. They are the chief forecasters of the Weather Bureau, and upon the character of their work must rest, in great measure, the value of the weather service. Their responsibilities are tremendous. At times the balance between life and death hangs upon their judgment, to say nothing of the saving or loss of millions of property. The warnings of a single storm moving up the Atlantic seaboard save hundreds of lives and from $3,000,000 to $5,000,000 of property during each storm, and there are a number of these storms each year. Since so much depends upon the skill and judgment of these men, it would certainly seem a wise economy to pay them a fair salary for their work—one even larger than recommended.

The chief of the proposed river and flood division will be charged with the supervision and proper conduct of the river service of the entire country, which even in its present partially incomplete state maintains over 300 river and rainfall stations. Losses by a single flood, such as the Kansas River flood of 1903, where no service is maintained on account of lack of the necessary funds, amount to more than the entire expenses of the river and flood service would amount to for a generation; and, conversely, the value of property saved by flood warnings where adequate service is maintained, such as that on the Ohio and Mississippi rivers during the spring of 1903, amounts to as much or more. These instances of the value and usefulness of this service are by no means isolated ones, but are repeated in greater or less degree several times annually. In the spring of 1897 the value of property saved during the Mississippi River flood as a result of the Weather Bureau warnings amounted, according to competent authority, to over $15,000,000, and during the present year even this enormous figure was exceeded.

No one can doubt the tremendous importance of this work or belittle its effect upon the economic progress and development of the country. The watershed of the Mississippi River alone comprises two-fifths of the total area of the United States proper; within its confines dwell more than 40 per cent of our population, and the great bulk of our staple crops are grown here. It is easy to perceive, therefore, that whatever affects the well-being of this vast area will be reflected, now for good and now for evil, throughout our entire domain. To properly conduct a service of this character demands ability, both scientific and executive, of a high order. It is a work that requires many years of education and study, a life work in reality, and it is not fair to expect that a capable man should continue in it with the extremely small salary of $2000 a year, a compensation much smaller than that given to many other Government officials whose duties are much less arduous and whose responsibility for each day ends with the close thereof.

CLIMATE AND CROP DIVISION.

The Climate and Crop Division has charge of the climate and crop service of the Weather Bureau, and of the distribution of its daily forecasts and special warnings. During the year ended June 30, 1903, its work was along established lines, no new feature having been added.

In the climate and crop work more than 3300 voluntary observers and nearly 14,000 crop correspondents furnish meteorological observations and weather and crop reports that are used in the compilation of the monthly climatic reports and weekly climate and crop bulletins of the various sections, while about 300 paid stations of the corn, wheat, cotton, sugar, rice, and fruit services render daily telegraphic reports to designated centers from which daily bulletins are issued during the crop-growing season.

In the dissemination of forecasts through the various means employed an average daily issue of about 200,000 weather forecast bulletins is accomplished. In the preceding year it was through the rural free-delivery service of the Post-Office Department that the greatest increase in forecast distribution was effected, but on account of lack of funds it was not possible to further extend the distribution through this very effective means of reaching the farmers. A large and very prompt dissemination has, however, been accomplished, without cost to the Bureau, through the farmers' telephone exchanges.

For a number of years past an extensive distribution of weather forecasts has been accomplished through the cooperation of postmasters supplied with logotype and stamping outfits, with which the brief weather messages are printed upon postal cards for mailing to outlying towns. While this system has served a most useful purpose, and will continue to prove valuable, urgent need has been felt for more rapid means of printing the forecasts.

Through the courtesy of the Director of the Census a sufficient number of copies of volumes containing agricultural statistics of the Twelfth Census was procured to supply each section center with a set consisting of Part I, Vol. V, and Part II, Vol. VI. The information contained in these volumes has been used to great advantage at the Central Office in determining the relative importance of the several States in the

production of the various crops, and will prove valuable to the section centers in the study of climate and crop problems.

NATIONAL CLIMATE AND CROP BULTELIN.

The national Climate and Crop Bulletin has been issued in the usual form, with charts showing the current temperature and precipitation, extremes of temperature, and departures from normal of both temperature and precipitation. In this bulletin the current meteorological conditions are discussed in their relation to crop growth from the beginning to the end of the crop season. So expeditiously are the reports of crop conditions and meteorological observations collected and utilized that within twenty-eight hours after the close of the week ending 8 a. m. on Monday, there is given to the public in this bulletin a graphic presentation of the temperature and rainfall conditions, together with a general summary of the weather and crop conditions for the United States, supplemented by a condensed summary for each and every State. In the preparation of the temperature and precipitation charts accompanying the national Climate and Crop Bulletin telegraphic data from more than 450 stations are used. The effect on the markets of the information contained in this bulletin is so decided that in order to place it before the public in an impartial manner it is withheld until 12 noon on the day of issue (Tuesday), when the complete report is equitably and gratuitously distributed to all desiring it. It is doubtful whether any class of information receives a wider dissemination through the daily and weekly newspapers and agricultural journals than the text matter of the national Climate and Crop Bulletin. The press associations and a large number of the more important newspapers of the country with representatives in this city are served with the bulletin as soon as the hour arrives for making the information public.

In order to more fully meet the need of the cotton interests an abridged form of the national Climate and Crop Bulletin, entitled "Cotton Region Climate and Crop Bulletin," is issued at New Orleans. This publication contains summaries of the climate and crop conditions prevailing in the States of the cotton belt, duplicates of which are published simultaneously in the national Climate and Crop Bulletin.

SECTION PUBLICATIONS.

The monthly climatic reports and the weekly climate and crop bulletins have been issued in conformity with the standard models adopted in 1896. In their present form they so satisfactorily meet the needs for which they are intended that no change seems advisable. The demand for both the monthly climatic reports and the weekly climate and crop bulletins, as well as for the daily bulletins of the corn, wheat, cotton, sugar, rice, and fruit services, is constantly increasing. So numerous have been the calls for the monthly climatic reports of previous years that the editions of very many sections have been exhausted, notwithstanding the fact that the section directors have been instructed to prepare for increased demands. These publications answer so fully and in such detail many questions pertaining to climate that were it not for them a much larger force of clerks would be required at the Central Office to supply requests for climatic data. The annual summaries are in especial demand. All weekly climate and crop bulletins are issued on Tuesdays, and the monthlies as soon as practicable after the close of each month. Most of the latter are ready from the 15th to the 20th, and practically all are issued by the end of the month succeeding that to which the report pertains. By a complete interchange of the monthly reports each section receives all the reports issued. These are carefully filed and are available for reference at all times. In addition to the section centers, 20 of the more important stations of the Bureau also receive these monthly reports, and it is frequently found a means of convenience to refer applicants for information contained in these reports to the nearest Weather Bureau station having a complete file.

SNOW AND ICE BULLETINS AND THEIR USES.

In the winter time there is issued from the Central Office a snow and ice bulletin, showing graphically the extent of the area covered with snow and the depth; also the thickness of ice in rivers and harbors. This bulletin has a wide circulation, as the information it contains has an important bearing upon the winter-wheat crop, on the ice trade, and on the manufacture of rubber goods, horseshoes, etc., goods the demand for which is largely governed by the prevalence of sleet or snow,

In the States of the semiarid region local snow bulletins are issued by each climate and crop section center from December to March. These bulletins show the amount of snow and the depth remaining at the close of each month, this information being of great importance as affording a reliable basis for calculating the water supply for irrigation during the succeeding season. In some States a small amount is expended in obtaining snow measurements at high altitudes of difficult access where it is impossible to secure voluntary service.

VOLUNTARY STATIONS.

While more than 200 voluntary stations were established during the year, the total number, 3355, is not quite so large as at the close of the previous year. This is due to the closing of many stations using nonstandard instruments in localities where the need for stations was not sufficiently urgent to justify their equipment with standard instruments. As in the past few years, efforts have been mainly directed toward standardizing and improving the outfits of voluntary stations rather than in increasing their number. The plan of inspecting voluntary stations inaugurated in the previous year has been followed vigorously, 481 stations having been inspected by section directors during the year. The importance of these inspections can not be too strongly emphasized. Nothing can contribute more to the successful work of a voluntary station than a personal interview between the observer and the section director. These inspections, therefore, have unquestionably contributed much to the elimination of defects that are liable to exist, however careful the effort may be to guard against them. While many voluntary observers thoroughly understand their duties and perform them in a most satisfactory manner, it is found that there are few stations at which there is no opportunity for needed suggestions or instructions. As the inspections made in the previous year were largely confined to stations that could be reached without cost to the Bureau for transportation, the average expense, per station inspected, during the year ended June 30, 1903, was somewhat greater than in the previous year.

CORN, WHEAT, COTTON, SUGAR, RICE, AND FRUIT SERVICES.

The number of these stations and the manner of reporting and publishing data therefrom continue unchanged. The value of these services is becoming more widely known each year, and numerous requests for the establishment of more stations are received from commercial organizations. Twenty-five additional stations can be advantageously placed in portions of the cotton belt not now well represented, and a like number of stations for the corn and wheat region service is also needed in the corn and wheat belt. Owing to the exceptionally mild weather conditions prevailing in the cotton belt during the autumn of 1902 the cotton interests felt the need of the reports from the cotton-region stations after the suspension of the service on October 31. Effort was made to meet this demand by a voluntary service, which was continued during November. Much difficulty was experienced during the spring of 1903 in securing the receipt at the district centers of the daily reports from substations in time to be included in the district averages telegraphed to other section centers, and efforts have been made to secure more satisfactory service. As a rule, however, many of the delayed reports are received in time to appear in the local bulletins although too late to be embodied in the district averages. The editions of the bulle-

tins are larger than in previous years on account of the increasing demands. That the information contained in these bulletins may be given to the various interests in an impartial manner, they are issued simultaneously at 11 a. m., seventy-fifth meridian time. A copy of each bulletin issued from corn, wheat, cotton, sugar, or rice centers is received at the Central Office, where all are carefully examined for errors or defects. The total number of corn and wheat bulletins issued daily during the season at 12 stations is 769, and the total number of cotton-region bulletins issued at 28 stations is 865.

The fruit and wheat service in California continues to supply the needs of the fruit and wheat interests of that State very satisfactorily. No bulletins other than those supplied to the press are issued, but through the circulation in the Pacific papers a wide dissemination of the data collected is secured.

DISTRIBUTION OF FORECASTS AND SPECIAL WARNINGS.

Inadequate appropriations have prevented any extensions in this important work, and of necessity we have been compelled to confine our efforts to maintaining the service already in operation, with its various ramifications, and to adopting suggested improvements which might be effected without additional expense to this Bureau.

While a reduction of 131 is shown in the number of stations receiving forecasts by telegraph or telephone at Government expense, this indicates no impairment in the efficiency of this class, for the points discontinued were unimportant as centers, or the substations were transferred to some equally well-located center of distribution, and very few, if any, interests were deprived of the forecasts by this action.

No change has been made in the system of emergency warnings, and the number of authorized stations remains the same as at the date of my last report. This statement also applies to the railway train service, there having been no change, of record, in this work during the past year.

The dissemination of forecasts over the telegraph lines of a number of the great trunk railroads has been continued, while the service has been discontinued by a few of the smaller roads, owing to increased business over their wires, entailing a decrease of about 200 in the number of places receiving the daily reports for posting in the railroad stations.

A marked increase (nearly 20,000) is shown in the number of places receiving forecasts by telephone without expense to the United States, and with the rapid extension of "farmers' telephone lines" (so called) opportunity is afforded for placing weather information directly in the homes of the more progressive agriculturists, as well as in the telephone exchanges of rural centers of population, where it is posted for the benefit of the general public. The managers of these local telephone lines seem to be very much interested in this matter, and with very few exceptions have given their hearty support, making the distribution as successful as possible. It is not difficult to secure the cooperation of these officials, as a statement of the fact that forecasts can be had gratis adds to the inducements which they can offer to prospective subscribers. The great advantages of this plan of dissemination are apparent when we consider the very early hour at which the forecast reaches the subscriber and the slight amount of labor involved in furnishing him with the information.

The list of places supplied with daily forecasts through the regular mails has been increased by nearly 4000, showing a healthy growth in this class, although no efforts have been made, owing to lack of funds, toward an extension. The post-offices receiving card forecasts by the logotype system are being charted on post-route maps in this division, and any irregularities that may appear are corrected, and any offices not receiving the forecasts that can be reached from any distributing center in time to make the information of benefit are added to the lists of the proper center. This branch of the work is confined, as a rule, to a. m. forecasts, which can be posted in the various offices before 6 o'clock p. m. of the day of issue. Some of the distributors display considerable ingenuity in their devices for saving time and labor in this work, and I wish to invite particular attention to the work done at Marshalltown, Iowa, where the cards and slips are printed in three colors, with the regular logotypes, on a rapid printing press invented by the distributor.

The following table shows the geographic extent of this work, as well as the changes, as compared with the distribution of the previous year:

Distribution of daily forecasts and special and emergency warnings.

States.	At Government expense.			Without expense to Government by—					
				Telephone.					
	Forecasts, daily.	Special warning.	Emergency warning.	Forecasts, daily.	Special warning.	Railway telegraph, daily.	Railway train service, daily.	Mail, daily.	Rural free-delivery service, daily.
Alabama	25	5	152	68	94	83	12	960	857
Arizona	3	1	0	2	0	0	0	0	0
Arkansas	26	7	118	4,025	2	12	0	523	250
California	120	15	0	32	177	356	0	2,405	3,228
Colorado	20	18	81	48	200	2	7	1,016	1,240
Connecticut	14	4	52	0	0	15	151	1,109	100
Delaware	9	0	25	0	0	32	0	68	720
District of Columbia	0	0	0	11	11	0	0	1,264	6
Florida	27	125	95	34	132	91	0	1,193	0
Georgia	38	42	268	26	76	222	41	1,520	970
Idaho	12	1	0	7	22	0	17	403	101
Illinois	111	28	524	1,867	264	131	459	2,992	7,532
Indiana	100	10	242	3,530	131	68	287	2,000	5,877
Indian Territory	10	0	5	20	20	0	0	152	0
Iowa	143	30	480	7,554	222	13	0	1,889	9,037
Kansas	72	6	217	315	169	30	15	964	3,841
Kentucky	34	37	102	131	20	21	0	3,122	75
Louisiana	25	45	71	9	22	8	0	940	25
Maine	24	5	46	6	20	0	77	1,635	1,120
Maryland	28	7	89	17	34	84	0	1,855	1,384
Massachusetts	25	21	71	12	50	1	331	2,923	10,125
Michigan	113	23	443	85	256	269	457	4,893	5,376
Minnesota	53	16	217	500	544	13	0	2,023	2,062
Mississippi	27	8	75	39	25	10	0	737	0
Missouri	86	11	280	3,640	182	36	0	4,232	6,310
Montana	16	3	24	6	16	0	0	504	0
Nebraska	63	11	241	406	49	0	0	936	1,415
Nevada	3	0	0	0	0	0	0	178	0
New Hampshire	17	1	39	0	0	0	31	1,281	1,205
New Jersey	29	22	127	6	22	189	0	1,406	255
New Mexico	4	2	0	0	0	9	0	15	0
New York	118	60	407	458	961	305	168	6,985	10,454
North Carolina	47	21	214	25	46	1	16	1,256	453
North Dakota	13	12	104	0	0	0	0	29	215
Ohio	125	93	407	2,249	1,787	37	17	8,289	14,292
Oklahoma	8	2	15	1	30	9	0	176	0
Oregon	18	2	0	0	32	0	104	646	695
Pennsylvania	52	22	345	799	358	727	0	4,290	485
Rhode Island	5	0	13	44	7	0	28	102	0
South Carolina	36	6	125	30	277	30	23	1,097	456
South Dakota	34	26	111	86	284	0	0	706	195
Tennessee	43	10	305	108	165	23	2	1,606	1,715
Texas	56	67	278	165	453	163	0	1,666	2,293
Utah	12	57	0	0	0	0	0	202	290
Vermont	11	1	50	0	0	8	13	542	100
Virginia	41	9	109	157	53	60	96	1,709	228
Washington	20	3	0	2	52	0	29	706	548
West Virginia	22	11	74	522	245	18	26	1,094	232
Wisconsin	71	16	447	1,503	92	0	16	1,820	1,852
Wyoming	6	4	8	6	0	11	0	105	40
July 1, 1903	2,015	926	7,096	28,251	7,602	3,087	2,423	78,164	97,648
July 1, 1902	2,146	921	7,096	8,297	12,872	3,280	2,423	74,327	105,161
Changes	−131	+5	0	+19,954	−5,270	−193	0	+3,837	−7,513

The decrease of 7500 in the number of families receiving forecast slips through the rural free-delivery service is due mainly to a change in the hours of departure of carriers from terminal points, which precluded their receiving the forecast telegrams in time for distribution, as it has been the policy of the Bureau to allow only the distribution of the a. m. forecasts, except in a limited number of cases where the circumstances justified a departure from this rule. When carriers leave before 8 a. m. and the distributing station has no "all night" telegraph office, there is no possibility of the messages being delivered in time to allow the forecasts to be duplicated and given to the carriers before their departure. There appears but one remedy for this, and that is to utilize the p. m. forecasts alone for rural free-delivery distribution, and have

carriers supplied by mail train with their slips from a regular Weather Bureau station equipped with a rapid printing press like those now in use at the Boston and Columbus stations.

The agricultural sections constitute one of our principal fields of operation, and the rural free-delivery is the means for reaching them. As stated in my previous report, it seems particularly unfortunate that, at this time, when the Bureau has opened up to it such a great opportunity for increasing its usefulness to the farming classes, we are debarred from taking the action indicated owing to insufficient appropriations. For reasons above stated we are compelled to refuse numerous requests for forecasts, which are being received from persons living on rural free-delivery routes.

The chief of the Climate and Crop Division has charge of some of the most important work of the Bureau, viz, the climate and crop service and the distribution of forecasts and special warnings. Fifty-two of the higher station officials are partially engaged in work under his general supervision. Paid observers at 293 stations of the corn and wheat, cotton, sugar and rice, and fruit services are under his exclusive direction, and nearly 30,000 persons serving gratuitously in the capacity of crop correspondents, forecast distributors, and voluntary observers contribute to the work under his charge. Approximately, one-third of the Bureau's appropriation for telegraphic purposes is expended annually in the collecting and disseminating work under his division. He writes the national Climate and Crop Bulletin, a work requiring skill in the handling of meteorological statistics and in the construction of temperature and precipitation charts, as well as ability to understand and intelligently discuss the effects of weather on growing crops. The State sections of the climate and crop service are under his supervision. There are 42 sections, each publishing monthly climatic reports the year round, and weekly climate and crop bulletins during the period of planting, cultivating, and harvesting of the more important staples.

I take this occasion to express my acknowledgment of the very valuable and efficient service of Mr. James Berry, chief of this division. His work in the climate and crop service demands a high order of intelligence and the utmost integrity, qualities which he possesses in an eminent degree, and which, when taken in conjunction with the importance of the work and his long experience of twenty-five years in the service of the Bureau, give him the strongest title to promotion. He now receives $2000, and I earnestly recommend his promotion to $2750. I make this recommendation in the earnest desire to deal justly with a man who has been a worthy assistant and most valuable public officer.

LIBRARY AND THE WORK OF THE LIBRARIAN.

The work of the library has gone on in general as outlined in my last report. During the year there have been added 987 title, bringing the catalogued strength of the library up to 24,138 books and 4430 pamphlets, making a total of 28,568 titles. These titles are represented by a complete author card index, and partly, about two-fifths, by a subject card index. It was expected that this subject index would have been completed during the year, but unavoidable contingencies prevented. A bibliography of current meteorological literature is now maintained, and a selected part of it appears regularly in the MONTHLY WEATHER REVIEW.

The steady flow of publications into the library from year to year has filled all available shelf room. Need of more room is urgent. The question has often been raised as to the limitation of the book accessions. As far as appears practicable restriction has been enforced. No works are purchased not clearly connected with the interests that the Bureau serves. By far the greater part of the accessions are the meteorological publications of other national weather services received in exchange for our own publications, and they are properly the objects for the custody and care of which we are most interested in providing.

EXAMINATIONS.

During the year 69 employees applied to be examined for eligibility for promotion, in accordance with a system of examinations adopted and in force for this purpose since 1899. Of these, 44 passed the examinations prescribed for eligibility for promotion to salary grade $1000 per annum, 6 failed; 13 passed the examinations prescribed for promotion to salary grade $1200 per annum, 2 failed; 8 passed the examination for promotion to salary grade $1400 per annum, 1 failed. One employee passed the examinations for promotion to both $1000 and $1200 per annum, and one passed the examination for all three grades. The topics of examination were: For promotion to salary $1000 per annum, grammar, arithmetic, elementary meteorology; for promotion to salary $1200 per annum, algebra, trigonometry, physics; for promotion to salary $1400 per annum, astronomy, plant physiology, and advanced meteorology. The duty of preparing and marking the questions has been performed by the librarian, in addition to the other duties devolving upon him.

These examinations serve a double purpose. First, as a review of statistics, almost all of the employees entering the weather service are young men. Many are from colleges; others have had less educational advantages, but have managed to pass the required entrance examinations. Experience has shown that even in the case of high school and college men there is often a lack of thorough grounding in the elementary subjects of English, arithmetic, and algebra. Because of such experience, it has been found well to require that these elementary subjects be reviewed, and for this reason they have been made part of the promotion examinations. The other purpose is that of showing that advancement is dependent upon the possession of a comprehensive knowledge of elementary meteorology and cognate sciences. Experience shows that the most useful officials of the service are those who keep themselves best informed, both as to the routine work of the Bureau and its relations to other interests.

INSTRUMENT DIVISION.

The duties of the Instrument Division may be embraced under the following heads: "Instruments," "Storm-warning towers," "Experimental work," and "Exposition work."

A station is rated as completely equipped when instruments are installed by which the following meteorological elements, wind velocity, wind direction, temperature, pressure, rainfall, and duration of sunshine, are continuously and automatically recorded.

During the past year new stations were fully equipped at Asheville, N. C.; Syracuse, N. Y.; Wytheville, Va.; Duluth, Minn. (substation); Concord, N. H.; Southeast Farallon, Cal., and Sand Key., Fla. The equipments of the stations at Alpena, Mich.; Amarillo, Tex.; Block Island, R. I.; Lynchburg, Va.; Roseburg, Oreg.; Wichita, Kans., and Williston, N. Dak., were brought up to a standard of completeness. There are now 138 stations completely equipped. Those remaining, numbering about 60, are either special agencies, or display stations at which anemometer records only are desired, or are of such minor importance that the present equipment is sufficient. A very considerable number of automatic instruments are, nevertheless, maintained at the incompletely equipped stations, some of which lack only a single instrument.

The following shows the total number of the principal instruments in active service:

Triple registers for wind direction and velocity, rainfall, and sunshine	161
Barographs (includes 35 in lake marine service)	220
Thermographs	162
Telethermographs	8
Tipping bucket gages	141
Electric sunshine recorders	145
Photographic sunshine recorders	30

Nearly all the stations that are completely equipped have,

in addition to the instruments mentioned above, certain duplicates, constituting an "Exhibit equipment."

The automatic instruments are operated almost wholly by electricity, and heretofore the current has been obtained from an improved form of primary battery consisting of zinc and oxide of copper elements in a solution of caustic soda. While they have proved vastly superior to the old "bluestone" batteries, yet their maintenance involved expense and trouble for recharging. Steps have been taken to introduce small storage batteries, which have now been brought to a high state of efficiency. Unfortunately, these storage cells can only be used at stations having a direct-current system of electric lighting. The original installation costs but a trifle more than one set of the ordinary primary batteries, and no further expense is necessary, since the batteries are charged from the lighting current. The use of the storage cells not only provides a more satisfactory source of electric energy, but also effects a saving of from $10 to $15 a year for each station. About 50 stations are now supplied with suitable current, and action is being taken to equip these with storage cells in the near future.

NEW SEISMOGRAPH.

It has long been the policy to maintain a special equipment of instruments at the Central Office in Washington. An instrument of unique interest is the seismograph. For a number of years practically the only instrument of the kind maintained in operation in North America was the one in the Weather Bureau. Several others existed, but because of the infrequent occurrence of earthquakes they were not kept in condition to make records, During the past year a new seismograph of modern design and of greatly improved type was procured and installed. A distinct earthquake was recorded March 15, 1903, and another of much larger duration on June 2, 1903. A detailed account of these shocks and a description of the seismograph has been published in the MONTHLY WEATHER REVIEW. Any considerable earthquake that occurs on any point of the globe is now pretty certain to be more or less fully recorded at Washington. Where seismographs of the degree of sensitiveness possessed by the one now in use have been maintained for periods of a year or more, a peculiar type of record has been traced from time to time which, as yet, is not fully understood. Omori, of Japan, classifies the phenomena as "pulsatory oscillations," and the opinion prevails generally that the origin of these waves is not seismic but meteorologic, and that it is probably connected with unusual conditions of atmospheric pressure. The records made in such cases show that the crust of the earth is in a state of continuous oscillation of appreciable amplitude. This motion goes on hour after hour, sometimes for a day or more at a time, but the data accumulated thus far are too meager to afford a satisfactory explanation of the phenomena. Colonel Bingham, in reporting upon the behavior of the long pendulum installed in the Washington Monument, states that "on many days of perfect calm the plumb line vibrates excessively, whereas on days when a high wind is blowing the plumb line will be at rest." There can be no doubt that the days on which the pendulum vibrates are days of pulsatory oscillations of the earth's crust at Washington. In the future such oscillations will be recorded on the seismograph.

STORM-WARNING TOWERS AND LANTERNS.

The duties of the Instrument Division, in connection with the storm-warning towers, are confined to the details of their purchase, installation, and maintenance. The selection of the stations and the management of the funds for the work are supervised by the Forecast Division. During the two preceding years the available funds have not been adequate for the entire work. Only a few stations were equipped last year, most of the funds being expended for high-power electric and oil burning lanterns, which were necessary to complete the equipment of a large number of stations at which towers had been erected. The improved equipment of storm-warning towers and lights is now completed at about 130 stations, and action is being taken to equip 25 additional stations during the fiscal year 1903-1904. When Congress was requested to appropriate for storm-warning towers the estimate of cost was based on about 125 stations. By the close of the year 1903 nearly 25 per cent more stations will have been fully equipped than were originally contemplated.

AERIAL RESEARCH.

A careful study of the mechanical, instrumental, and engineering problems involved in aerial research was entered upon by Professors Abbe and Marvin, and it was pushed as rapidly as their other duties would permit. The problem has been carefully studied in order that no blunder might be made that would develop after the work of the taking of observations had begun. A series of experiments was begun with small rubber balloons, for the purpose of testing the elasticity and other qualities of thin rubber. Investigations were made into the sluggishness of such forms of thermographs as might be used in ascensions. This is a work that can not be neglected. A thermograph rising or falling rapidly through the air is exposed to a constantly changing temperature, and, owing to its sluggishness, the indicated temperature is more or less seriously in error. If the coefficient of sluggishness under the different conditions of usage can be ascertained the proper corrections can be applied to the records. The instruments may then be caused to ascend or descend rapidly through the air (1000 feet per minute or more) and correct records be still obtained. This means quick and high ascensions and a more certain recovery of the apparatus. The following summary indicates what has been done:

Toluene thermometers, according to the hydrogen scale of International Bureau adjusted to —70° C., procured for comparison of instruments.

Special vacuum low temperature chamber designed and constructed for study of thermograph and barograph under simultaneous low temperatures and pressures.

Specimen rubber balloons of European manufacture procured.

Numerous tests made of surface tension, pressure, density, etc., of small rubber balloons.

Special type of platinum resistance thermometers and direct reading indicator, for use in the vacuum low temperature apparatus, devised and constructed.

Several types of European baro-thermographs procured for test and inspection.

The construction of netting, parachutes, etc., and disposition thereof, carefully studied.

Investigations made in the electrolytic generation of hydrogen, the best type of engine for the work, and the problem of easily and quickly testing the composition of the gases.

The theory of the sluggishness of the thermographs was formulated and apparatus and methods of measuring sluggishness developed and applied.

The study of the diffusion of hydrogen through thin sheets of rubber was begun.

The policy recently inaugurated of building up a great center of meteorological research at Mount Weather is undoubtedly one of the most important steps that have been taken at any time in the history of the Bureau to place the scientific side of the service upon a firm basis, and it is certain to bring valuable results. The importance of a careful study of all details in any way connected with instruments or apparatus is recognized, as the future suitability of installations depends upon their broad adaptability to many and diverse uses.

EXPOSITIONS.

The Instrument Division has been charged with the immediate care of the exhibits made at Buffalo, Charleston, Providence, and the one to be made at St. Louis. The instrumental section of the Buffalo exhibit was transferred to Charleston and later to Providence.

DIVISION OF METEOROLOGICAL RECORDS.

The routine work of examining meteorological forms from

regular and cooperating stations, and entering the data in the record books; preparing and tabulating data for the MONTHLY WEATHER REVIEW, for the Annual Summary of the WEATHER REVIEW, and for the Annual Report of the Chief of Bureau; preparing error letters to employees of the Bureau and cooperating observers; receiving and checking the receipt of regular and voluntary forms; preparing data for certification under seal of the Department for use as evidence in cases at law before the various courts of the country, and for many other purposes, has continued throughout the year. There are 3173 reports from voluntary observers examined each month.

A set of division tables, adapted from tables submitted by Mr. H. W. Smith, Mr. Arthur Thompson, and Mr. Hermann Volker, were published. This was a task requiring great accuracy in verification of figures and much time in preparation. The tables will be a great aid to speed and correctness in preparing forms at stations, and are satisfactory.

There is now being prepared, under the supervision of this division, a new series of climatic charts.

Temperature normals—mean daily values—for all stations for the twenty-five year period, 1879–1903, inclusive, are now being prepared. The initial portion of this work necessitated the entering of each day's mean at all stations for the years 1896–1903, inclusive. At stations having less than a twenty-five-year record, an arbitrary correction will be used, which will be arrived at by taking the means of identical years at contiguous stations, finding the difference from the twenty-year mean, then applying the mean correction of all the stations under consideration to the mean of the short period, thus making it comparable with stations having a full twenty-five-year record. The daily values of the short-record period will be fixed by taking the curve for some adjacent station whose temperature conditions are believed to be about the same as at the station under discussion.

In working up these daily values much time has been saved and great accuracy obtained by the use of an adding machine.

New precipitation normals, also, are being prepared for all stations, and determined from the beginning of record to the year 1903, inclusive.

An unusual amount of data was prepared for the committee on the Charles River Dam, of Boston; the waterworks department of New York City; for several Bureaus and Divisions of the Department, and the United States Geological Survey; for business people, invalids, health and pleasure seekers, etc.; and many calls for data from civil and hydraulic engineers, etc., have been filled by furnishing publications of the central office, climate and crop centers, and individual stations.

An increase of 2 clerks at $1000, 2 at $840, and 1 at $720 per annum is recommended to do the additional work imposed on this division by the increasing demands for data and to verify the records received from the new stations established during the past several years.

MONTHLY WEATHER REVIEW AND WORK OF THE EDITOR.

Professor Abbe has devoted his time to editing the MONTHLY WEATHER REVIEW and making the preliminary arrangements for the inauguration of a systematic research into the meteorological conditions of the upper air by means of kites and special small hydrogen gas balloons. The aerial investigations, however, have recently been assigned to Professor Bigelow.

The MONTHLY WEATHER REVIEW has continued to be published as promptly as possible, the number for April, 1903, appearing on June 20, 1903, being five days after the prescribed date. New type, improved presswork, and a better quality of paper have added much to the attractiveness of the publication. Many articles published in the REVIEW have been in such demand by students and scientists that separate prints have been made of them.

A memoir by Dr. J. W. Sandström, of Stockholm, on the construction of isobaric charts at high levels in the atmosphere and their significance in the dynamics of the atmosphere, has been translated and prepared for publication as an independent bulletin, as it is rather too large to go in the MONTHLY WEATHER REVIEW.

The following articles that seem worthy of mention appeared in the REVIEW during the past year:

W. A. Bentley: "Studies among the snow crystals during the winter of 1901–2." This article was published in the last number of Vol. XXX, or the Summary for 1902; it contains an analysis of the types and frequency of types of snow crystals, notes on their internal structure, and on the relation of the types to the location and distance of the storm center. With this was published a collection of 255 photomicrographs of snow crystals, engraved by the half-tone process and printed with great care, so as to bring out as far as practicable many of the details of internal structure that were to be seen on the original photographs. This beautiful memoir has received much praise, and many special requests for it have come to hand.

R. A. Harris: "Note on the oscillation period of Lake Erie" (June, 1902), and "The semidiurnal tides in the northern part of the Indian Ocean" (April, 1903). These papers explain certain oceanic tidal phenomena by the oscillation of the whole mass of water as a unit in lakes or certain parts of the ocean. Similar oscillations occur in the atmosphere when it is resting quietly, as may easily be observed by means of layers of smoke or fog.

Prof. F. H. Bigelow: "A contribution to cosmical meteorology" (July, 1902); "Studies on the meteorological effects of the solar and terrestrial physical processes" (December, 1902); "Synchronous changes in the solar and terrestrial atmospheres" (January, 1903); "The structure of cyclones and anticyclones on the 3500-foot and 10,000-foot planes for the United States" (January, 1903); and "The mechanism of countercurrents of different temperatures in cyclones and anticyclones" (February, 1903). These papers represent an immense amount of study and labor, and have undoubtedly given precision to our ideas as to the conditions prevailing in the general atmosphere and in the midst of the highs and lows. Extra charts have been published in the REVIEW, so as to more fully elucidate Professor Bigelow's conclusions and accustom the forecasters of the Weather Bureau to the careful study of the isobars and isotherms at high levels.

A. L. Rotch: "The International Aëronautical Congress at Berlin" (July, 1902). This is a full report on the congress of May, 1902, made by Mr. Rotch, as representing the United States Weather Bureau. This congress offered our first opportunity to learn of the success of the Berlin meteorological office in using small rubber balloons for carrying meteorographs to the greatest possible heights. It also showed that European meteorologists were unanimous and enthusiastic in their cooperation in the investigation of the conditions prevailing in the upper atmosphere. Hypotheses on this subject can no longer be acceptable, in view of the actual knowledge gained and the unexpected facts revealed by the work done with kites and balloons.

L. Teisserenc de Bort: "The Franco-Scandinavian station for aërial soundings" (April, 1903). Our distinguished colleague here gives us the first detailed account of the station established at Viborg, Denmark, by the cooperation of France, Denmark, Norway, and Sweden. Balloon and kite ascensions were made as often as possible during one year, and the results were promptly printed, although it is not known that they have as yet been distributed or published.

S. R. Cook: "The permanency of planetary atmospheres according to the kinetic theory of gases" (August, 1902). This is virtually an inquiry into the origin and history of the evolution of the earth's atmosphere. Mr. Cook's investigations confirm some of the calculations previously made by others, and he concludes that, in general, helium forms a constituent, though a very small part, of the earth's atmosphere; helium will be retained by the earth's attraction at much higher temperatures than now prevail. All the planets can retain atmospheres similar to the earth's, and the superior planets can retain gases much lighter than hydrogen. The vapor of water will remain on the planet Mars at ordinary temperatures. If the moon had a mean temperature as low as that of freezing water, it would lose any nitrogen and oxygen that it might have in its atmosphere.

L. N. Jesunofsky: "Some peculiarities in frost formations" (October, 1902). The author gives details as to numerous irregularities in the formation of frost in the neighborhood of Charleston, S. C. These are evidently due to local peculiarities in the soil and plant covering, as also to the presence of small regions of moist air following slight haze or fog, but in many respects they have not yet been satisfactorily explained.

B. C. Webber: "November gales from the Great Lakes to the Maritime Provinces" (November, 1902), and "March winds" (March, 1903). These two articles by the acting director of the meteorological service of Canada called attention to interesting peculiarities in our winds. They have also given occasion to the following paper by Mr. Stockman.

William B. Stockman: "March and winter winds" (May, 1903). In this article the author shows that the windstorms of the winter months occur with temperatures above normal, and that storms are more fre-

quent in March than in the winter months, except in the east Gulf and Atlantic coast States, the lower Lake region, and the upper Ohio Valley.

T. H. Davis: "Annual wind resultants" (November, 1902), and "Typical October winds on our Atlantic coast" (April, 1903). Mr. Davis has spent his spare time for many years in computing the resultants of the wind direction, both for hourly records and for tridaily records at our observing stations. He shows that at many stations the oscillations of the wind resultants go through a system of systematic changes from year to year, and that at neighboring stations these changes are analogous, but at distant stations they may be in opposite directions at the same time. For stations such as Key West and Bermuda, where the strictly local influences are uniform, the changes in the wind appear to depend upon changes in the so-called general circulation of the atmosphere. Mr. Davis is not able to find any special connection with changes in the sun spots or the moon or other cosmical phenomena. He maintains that the dignity of meteorology as a science can be maintained only by adhering closely to observed natural phenomena and avoiding popular discussions of suppositious events.

A. H. Thiessen: "An explanation of wireless telegraphy" (December, 1902). This article is very plainly written and abundantly illustrated; it has been widely praised as a very clear, simple, popular, and scientifically correct exposition of a subject in which all are interested and which may eventually become of great importance in the daily work of the Weather Bureau.

S. J. Allen: "Radio-activity of freshly fallen snow" (December, 1902). The author has extended the work of C. T. R. Wilson, on freshly fallen rain, and has shown that snow as well as rain brings down a radio-active substance from the upper atmosphere. It follows, from the researches of Elster and Geitel and J. J. Thomson, that this radio-active substance must consist of molecules charged with negative electricity, or the so-called negative ions. As moisture condenses most easily on the negative ions, it should follow that in the upper atmosphere there is left behind an excess of positive ions, or positive electricity, thereby explaining the existence of the so-called atmospheric electricity.

H. Ebert: "Atmospheric electricity considered from the standpoint of the theory of electrons" (May, 1903). This is the best popular exposition that has as yet been published on the present state of our knowledge of atmospheric electricity. It enables us to understand the many difficulties that have hitherto stood in the way of utilizing observations of atmospheric electricity for storms and other predictions. It also furnishes ground for hope that the new methods of observation perfected by Elster and Geitel and Ebert will make it possible to obtain from many stations electrical data that shall be comparable among themselves and be useful in the work of forecasting. As Ebert says, "We have acquired a point of view that promises to contribute very much to the solution of problems that are centuries old."

H. H. Kimball: "Abnormal variations in insolation" (May, 1903). As one of the results of Mr. Kimball's work at Asheville, N. C., he was able to point out that during January, February, and March, 1903, there was received at his locality decidedly less solar heat than was to be expected. A similar observation was made by Monsieur Dufour at Lausanne, Switzerland, and some irregularities of the same kind at Montpelier, France, in the years 1884–1886 were pointed out by Mr. C. G. Abbot in the MONTHLY WEATHER REVIEW for April, 1902. It is at present impossible to state with certainty whether these sudden diminutions in insolation are due to changes on the sun's surface or to increased absorption in special parts of the earth's atmosphere. The latter idea is the most plausible, and it remains to be ascertained whether the absorption was produced by dust and moisture in the atmosphere, and if so, where these came from.

W. N. Shaw: "Meteorological observations obtained by the use of kites" (May, 1903). The importance of the atmospheric data attainable by the use of kites is appreciated more highly every year. Considerable work of this kind was accomplished under the auspices of the Royal Meteorological Society during July and August, 1902, by forty kite ascensions from the deck of a tug steaming off the west coast of Scotland. Mr. Shaw furnishes an abstract of the results, showing especially the temperature gradient for each 500 meters of vertical height above the surface of the ocean; the average gradient is almost identical with the so-called adiabatic rate for saturated air and also with the temperature gradient used in reducing temperatures to sea level, viz, 1° F. per 300 feet, as originally adopted by Espy and still used in England. The author adopts the explanation that for these lower altitudes the air flowing from the ocean eastward and forced to rise above the Scottish mountains must be mechanically raised, and becomes, therefore, practically subject to the adiabatic gradient, which is not reached in the free atmosphere, except when the air is rapidly rising or falling. The most remarkable result of the highest balloon explorations has been to show that at great elevations the air is also frequently found to show the adiabatic gradient of temperature, and must, therefore, be recognized as probably in a state of rapid rise or fall.

Prof. J. R. Plumandon: "Cannon and hail" (Summary, 1902). As the reports of the various international conferences on the efficiency of cannonading against hailstorms have been frequently misquoted, Professor Plumandon, as secretary of the congress, has prepared this summary of results, and concludes with this admonition to American readers: "Before undertaking the protection of your crops by cannonading wait until that method of protection has furnished good results in the countries where it is now being tried."

Louis Besson: "The vertical component of the movement of clouds" (January, 1903). The general use of the nephoscope in determining the heights and movements of clouds is so important that this contribution to the literature of the subject is very welcome. The so-called vanishing-point nephoscope, described by Professor Abbe in his "Treatise on meteorological apparatus and methods," can be used with especial convenience to carry out the investigation described by Mr. Besson; it did, indeed, as there stated, as early as 1872, lead to the visible demonstration of the fact that in the neighborhood of the center of low pressure the clouds on opposite sides of the horizon have slightly different movements, both horizontally and vertically, so that the presence and location of the central low is easily determined.

J. R. Benton: "Elasticity at low temperatures" (January, 1903). The results of this memoir bear directly upon the construction of meteorographs for use in the low temperatures that are continually occurring in meteorology. The author shows that steel springs may be relied upon at temperatures where other materials fail, and that the law of change of elasticity is quite regular, though not as great as the change that takes place in india rubber or in fusible metals.

Prof. A. G. McAdie: "High wind records on the Pacific coast" (February, 1903), and "High winds at Point Reyes light" (May, 1903). In these articles, with the accompanying note by Professor Marvin, we have apparently reliable records of northwest gales whose extreme velocity measured 120 miles per hour during gusts of a minute's duration, and whose movement for a whole hour was 78 miles. For eight consecutive days the velocity varied between 46 and 70 miles per hour. The fact that such a record can be maintained without interruption is a high tribute to the excellence of the anemometer, the recording apparatus, and the faithful attention given to these by the observer, Mr. W. W. Thomas.

Charles A. Mixer: "The water equivalent of snow on the ground" and "River floods and melting snow" (April, 1903). These papers give exact data in reference to an important subject on which we have hitherto had indefinite ideas. The snow lying on the ground at the end of winter is in many locations the sum total of the winter snowfall, only slightly diminished by an occasional thaw and compacted into a dense mass. The sudden melting of this snow in the warm weather and sunshine of spring, and especially by the influence of the warm spring rains, forms the most important constituent of dangerous spring floods in our northern rivers. Mr. Mixer very properly urges that every rainfall and river station should keep a record of the water equivalent of the snow lying on the ground, just as it does of each fresh snowfall. In some cases quoted by him 38 inches of snow on the ground gave 10.5, 20 inches gave 9.8, and 90 inches gave 6.3 inches of water.

E. Buckingham: "On the radiation formulas and on the principles of thermometry" (April, 1903). This is an exposition of the proper method of applying various empirical formulas for the observed quantity of radiation from any surface to the determination of the actual temperature of the radiating surface. Dr. Buckingham's exposition is applicable, not only to the determination of the temperature of the surfaces from which radiant heat is received, but also to the investigation of the theory of the errors of Ångström's pyrheliometer of similar apparatus.

D. T. MacDougal: "The influence of light and darkness upon the growth and development of plants" (April, 1903). This is a summary by Dr. R. H. Pond of the results attained by Professor MacDougal in many years of most careful experimentation. The subject is one that is fundamental in the study of the relation between climatology and plant life, and it prepares the way for the proper study of many problems in the economy of plant life, and for the intelligent application to the needs of the farmer of the observed Weather Bureau data relative to sunshine, cloudiness, temperature, and rainfall.

Henry L. Abbott: "Climatology of the Isthmus of Panama" (March and April, 1903). In these articles General Abbott, by combining all accessible information, has been able to give a rational explanation of the observed oscillations of rainfall, temperature, and wind in this tropical region. He has also been able to deduce reliable values of the monthly and annual mean barometric pressures reduced to sea level.

H. W. Richardson: "Composite and other arrangements of weather types" (February, 1903). In this paper the author explains the methods he has used for several years in collecting together weather maps of the same type and assorting them for study. He classifies them as composite and associate types. He notes that there is an apparent tendency of the centers of high and low areas to move (in twenty-four hours) from the center of an area of positive or negative twenty-four-hour pressure change to the edge of the same area.

W. M. Fulton: "The automatic river gage at Chattanooga, Tenn." (May, 1903). This apparatus, as invented by Mr. Fulton, consists of two parts, one at the river which measures the stage of water, and the other at the Weather Bureau station which records the stage of water. The two parts are connected by a telegraph line. Analogous apparatus has been constructed from time to time by others for recording both river and other natural phenomena, but as a rule the difficulty of maintaining the line intact and the uncertainty of electrical apparatus in general has

led to the abandonment of the method. In the present case Mr. Fulton has overcome several instrumental difficulties, and as the apparatus has worked satisfactorily for several months, copies of it have been desired for other stations.

Weather Bureau men as instructors: Among the numerous "Notes by the editor," attention is especially called to those dealing with the work done by employees of the Bureau along educational lines. Rather elaborate courses of instruction are given at Columbian University, Washington, D. C.; the University of Cincinnati, Cincinnati, Ohio; the Medical College of Virginia, Richmond, Va.; the Buchtel College, Akron, Ohio; Johns Hopkins University, Baltimore, Md.; the medical department of the University of Missouri, Columbia, Mo.; the Kentucky State College, Lexington, Ky.; Norwich University, Northfield, Vt.; the Ohio State University, Columbus, Ohio; Yale University, New Haven, Conn.; Cornell University, Ithaca, N. Y.; Mercer University, Macon, Ga.; the University of Tennessee, Knoxville, Tenn.

In all these cases the course of instruction averages about two hours per week during at least four months, or one hour weekly for the whole college year. In general, the educational work is so arranged as not to interfere with official station duties and is done without additional compensation, except that in some cases a small honorarium is offered. Further details are given in the MONTHLY WEATHER REVIEW for April, 1903.

PYRHELIOMETRIC MEASUREMENTS.

Mr. H. H. Kimball, assistant editor, was sent to Asheville, N. C., with an Ångström pyrheliometer. Under arrangements made by Professor Abbe, he took observations at stated hours each day from November 10, 1902, until March 26, 1903, at Asheville and Black Mountain, N. C. The observations were carried out with faithfulness, and the report, including a complete tabulation of the observations and reductions, has been rendered by Mr. Kimball. The observations made in 1901–1902, with a similar instrument, by Messrs T. H. Davis and Robinson Pierce, jr., under the general direction of Prof. Carl Barus, at Providence, R. I., have also been submitted in a report by Mr. Davis. The solar radiation, as measured by this apparatus, is that which is actually received by every object at the earth's surface; the datum is directly applicable to problems in agriculture as well as to meteorology, and an effort will be made to explain its usefulness, in an early number of the MONTHLY WEATHER REVIEW. The actual amount of solar energy received at the outer limit of the atmosphere can also be obtained from this observed datum, after we have learned how to interpret it by the study of the bolometric work that is carried on continuously by Professor Langley.

POLARISCOPIC OBSERVATIONS.

In connection with the pyrheliometer, Mr. Kimball maintained a series of observations with the Pickering polarimeter, loaned by the observatory of Harvard College. The blue color of the sky and the polarization of the light depend alike on the fact that the atmosphere is a mechanical mixture of several gases and is loaded with vapor, haze, and dry dust. The polariscope gives us a basis for calculating the relative quantity of these impurities. Professor Abbe is of the opinion that Mr. Kimball's work may establish a connection between the polarization and the atmospheric absorption. The observations were found to indicate a decided diminution in the heat received from the sun during the months of January, February, and March, 1903, a fact that he was able to announce even before the publication of a similar observation made at Lausanne, Switzerland, by H. Dufour.

DIVISION OF ACCOUNTS AND DISBURSEMENTS.

In regard to Mr. Almerico Zappone, assistant chief of the Division of Accounts and Disbursements of the Department, who is assigned to charge of the accounts of the Weather Bureau, I desire to make a special recommendation. During a long experience in the Weather Bureau service (twenty-three years) this official has been distinguished by his exemplary conduct and a most faithful and intelligent performance of the exacting duties devolving upon him. In three Bureaus, whose appropriations are comparable with the appropriation made for this service, the salaries paid to the disbursing officials are greater than Mr. Zappone's by $500, although, with one exception, the money handled by him at this office is in excess of that handled in the others. His work is also subject to the supervision of the Disbursing Officer of the Department, and I have every reason to believe that that officer will join me in the earnest recommendation I now make that Mr. Zappone's salary be advanced from $2000 to $2500 per annum.

BUILDINGS ERECTED, REPAIRED, AND IMPROVED.

During the past two fiscal years, through the appropriations by Congress, it has been possible to erect buildings for use as meteorological observatories for the Weather Bureau at the following-named places:

Atlantic City, N. J.:	
Cost of lot (Government reservation); cost of building	$6,000.00
Hatteras, N. C.:	
Cost of lot, $125; cost of building, $4,875	5,000.00
Fort Canby (North Head), Wash.:	
Cost of lot (Government reservation); cost of building	3,992.63
Port Crescent, Wash.:	
Cost of lot (Government reservation); cost of building	1,000.00
Tatoosh Island, Wash.:	
Cost of lot (Government reservation); cost of building	4,950.00
Point Reyes, Cal.:	
Cost of lot (Government reservation); cost of building	2,989.90
Amarillo, Tex.:	
Cost of lot, $1,255; cost of building, $6,503	7,758.00
Modena, Utah:	
Cost of lot (Government reservation); cost of building	4,346.00
Key West, Fla.:	
Cost of lot, $2,020; cost of building, $7,994.75	10,014.75
Sand Key Island, Fla.:	
Cost of lot (Government reservation); cost of building	5,593.00
Southeast Farallon, Cal.:	
Cost of lot (Government reservation); cost of building	5,211.22
Mount Weather, Va.:	
Cost of lot, $1,413.90; cost of building, $15,663.13	17,077.03
Total	73,932.53

In addition, it has been possible to repair and improve the followiing buildings at the total cost set opposite each, viz:

Bismarck, N. Dak	$7,064.14
Jupiter, Fla	3,358.00
Kittyhawk, N. C	125.00
Cape Henry, Va	5,104.25
Total	15,651.39

BUILDINGS IN COURSE OF ERECTION.

Buildings are now in course of erection at the following places:

Yellowstone Park, Wyo.:	
Cost of lot (Government reservation); cost of building	$11,500
Duluth, Minn.:	
Cost of lot, $2,100; cost of building, $7,900	10,000
Devils Lake, N. Dak.:	
Cost of lot, $2,300; cost of building, $8,000	10,000
Havre, Mont.:	
Cost of lot, $1,850; cost of building, $5,700	7,550
Mount Weather, Va.:	
Cost of lot, $650; cost of building, $10,000	10,650
Block Island, R. I.:	
Cost of lot, $1,100; cost of building, $7,700	8,800
Narragansett Pier, R. I.:	
Cost of lot, $4,100; cost of building, $8,000	12,100
Total	70,000

AREA OF LAND OWNED BY THE WEATHER BUREAU.

The wisdom of the Weather Bureau in erecting and owning its own buildings becomes more apparent each day. It not only saves to the Government the amount heretofore paid for rent of office quarters, which in many cases are unsuited to our needs, especially as regards the architecture of the roofs for the exposure of meteorological instruments, but places the Weather Bureau on a footing of equality with other branches of the Government service, such as the Light-House Board and Life-Saving Service. Aside from this, these buildings provide living accommodations for our employees, who are so often required to remain on duty both day and night, add

dignity to the service, and compel more respect from the general public.

The area of land purchased by the Weather Bureau during recent years, or transferred to that Bureau by the various branches of the Government, is as follows:

		Area.
Atlantic City, N. J	square feet	5,000
Cape Henry, Va	acre	$\frac{1}{2}$
Hatteras, N. C	do	$\frac{1}{5}$
Jupiter, Fla	do	$\frac{1}{8}$
Kittyhawk, N. C	do	$\frac{1}{4}$
North Head, Wash	do	$\frac{1}{5}$
Point Reyes Light, Cal	do	$\frac{1}{2}$
Port Crescent, Wash.	do	1
Sault Ste. Marie, Mich	square feet	2,000
Tatoosh Island, Wash	acre	$\frac{1}{5}$
Yuma, Ariz	do	1
Amarillo, Tex	do	$\frac{2}{5}$
Key West, Fla	do	$\frac{2}{5}$
Bismarck, N. Dak	acres	3
Sand Key, Fla	square feet	2,500
Southeast Farallon, Cal.	acre	$\frac{1}{5}$
Mount Weather, Va	acres	$77\frac{1}{4}$
Modena, Utah	acre	1
Yellowstone Park, Wyo	do	1
Duluth, Minn	do	$\frac{1}{2}$
Devils Lake, N. Dak	do	$\frac{2}{5}$
Havre, Mont	do	$\frac{1}{5}$
Block Island, R. I	acres	$1\frac{1}{4}$
Narragansett Pier, R. I	do	$1\frac{1}{3}$
Total area (about)	acres	94

PROPOSED BUILDINGS.

It is planned to erect buildings at all places where the service is now represented and is paying rent for office quarters, if the population of the place is less than 25,000, and it is hoped that Congress will continue to appropriate a small amount for the purpose annually. It is found that when the population of a place is under 25,000 it is a difficult matter to get suitable accommodations, with good roof facilities, and as a result the accuracy of observations is often affected.

When buildings are thus dotted over the country and equipped with modern self-registering apparatus we can truly say that the weather service of the United States is the finest in the world.

The following list shows the places under 25,000 population where the Government is now paying rent for Weather Bureau accommodations, and where buildings should be erected:

Places where buildings should be erected.

Place.	Population.	Rent paid.	Place.	Population.	Rent paid.
Abiline, Tex	3,411	$381.80	Moorhead, Minn	3,730	$265.25
Alpena, Mich	11,802	211.36	Mount Tamalpais, Cal	....	420.00
Asheville, N. C	14,684	300.00	Nantucket, Mass	3,006	263.00
Baker City, Oreg	6.683	450.00	North Platte, Nebr	3,640	339.50
Birmingham, Ala	24,000	720.00	Oklahoma, Okla	10,037	510.00
Boise, Idaho	5,957	480.00	Palestine, Tex	8,297	314.00
Cape May, N. J	2,257	420.00	Phoenix, Ariz	5,544	480.00
Cheyenne, Wyo	14,087	620.00	Pierre, S. Dak	2,306	240.00
Columbia, S. C	21,108	360.00	Pocatello, Idaho	4,046	360.00
Concord, N. H	19,632	300.00	Raleigh, N. C	13.643	240.00
Concordia, Kans	3,401	292.00	Rapid City, S. Dak	1,342	378.00
Corpus Christi, Tex	4,703	259.00	Red Bluff, Cal	2,750	396.25
Dodge, Kans	1,942	355.65	Roseburg, Oreg	1,690	339.00
East Clallam, Wash	32	72.00	San Diego, Cal	17,700	384.00
Elkins, W. Va	2,016	288.00	San Luis Obispo, Cal	3,021	300.00
Escanaba, Mich	9,549	540.00	Santa Fe, N. Mex	5,603	420.00
Eureka, Cal	7,327	368.80	Tampa, Fla	15,839	328.75
Fresno, Cal	12,470	378.00	Taylor, Tex	4,211	575.00
Flagstaff, Ariz	1,271	600.00	Twin, Wash	....	100.00
Grand Junction, Colo	3,503	480.00	Valentine, Nebr	811	420.00
Green Bay, Wis	18,684	297.00	Walla Walla, Wash	10,049	310.80
Helena, Mont	10,770	588.00	Wichita, Kans	24,671	340.00
Houghton, Mich	3,359	375.00	Williston, N. Dak	763	450.00
Huron, S. Dak	2,793	500.00	Winnemucca, Nev	1,000	268.00
Independence, Cal	407	360.00	Wytheville, Va	3,003	400.00
Kalispell, Mont	2,526	270.00	Yankton, S. D	4,125	300.00
Lander, Wyo	737	351.00			
Lewiston, Idaho	2,423	420.00	Total amount of rentals	....	21,089.16
Lynchburg, Va	18,891	250.00			
Marquette, Mich	10,058	360.00	Total cost of buildings and sites	....	570,000.00
Miles City, Mont	1,938	300.00			

During the past several years Congress has authorized the construction of five or six observatories each year. It is recommended that the appropriation for this purpose be the same as last year, $50,000.

DIVISION OF PUBLICATIONS.

Printing of weather maps, forecast cards, meteorological forms, and bulletins was continued as usual.

The printing of postal cards decreased from 31,000,000 to 20,000,000, but the number of paper slips used in the distribution of forecasts by free rural carriers increased from 15,500,000 to 25,000,000.

Over 55,000,000 pieces of printed matter were sent out, of which 20,000,000 were prepared in the office of the Bureau; the remainder were printed at the Government Printing Office. In this number are included 8,500,000 station maps, one-half of which were printed at the Bureau.

The MONTHLY WEATHER REVIEW has been given a complete new typographical dress and a fine quality of paper has been adopted, so that its mechanical appearance has been greatly improved.

A duplicate dynamo has been installed, and the efficiency of the engines has been increased by about 8 horsepower as a result of belting them direct to the generators.

DIVISION OF SUPPLIES.

The operations of this division embrace the drawing of requisitions for supplies for the use of the Bureau; the receipt and inspection of the same; the drawing of transportation requests for transportation of supplies to and from stations; the examination of all accounts for purchase and transportation; the keeping of the record of all supplies received by purchase and otherwise, either in this city or at stations; the examination of property returns rendered annually, showing the accountability of observers for public property in their custody; the disposition of useless and condemned property, and the rendition annually of returns of all property used in the Bureau and for issue to stations. These duties have been well performed.

In accordance with plans made several years ago, and which have been generally put into effect, nearly all stations are now equipped with first-class standard furniture and equipment, thus putting the stations in a far better working condition than ever before.

SUPPLIES AND EQUIPMENT FOR CENTRAL OFFICE.

In caring for the buildings and grounds occupied by the Weather Bureau in the city of Washington, the additional sum of $3000 will be required during the next fiscal year. In 1894 the amount appropriated for this purpose was $9700 (including hire of laborers, $2800); in 1903 the amount was $10,000, and for the present fiscal year it is $6000 (the salaries of the laborers previously on that roll, amounting to about $4000, having been transferred to the statutory roll of the office), from which it will be seen that the actual sum available for repairs and improvements to the buildings and grounds during the present fiscal year is less than it was eleven years ago, while the cost of materials has advanced and the buildings have deteriorated. The increased cost of fuel alone for the present year is about $500, and the total amount required for fuel and gas is $3500, leaving only $2500 for repairs to the buildings and grounds, which is insufficient for the purpose. The main building is in need of extensive repairs to preserve it; the storehouses and annex buildings erected a few years ago now require repairs; a plant for burning hard coal is needed in order to comply with the District law in regard to smoke; and the grounds are also in need of improvements to preserve them, especially the old concrete roadways, which should be replaced. These matters have been deferred for several years, but now require attention.

In supplying the necessary furniture, stationery, and other supplies for the equipment of the Central Office the additional sum of $3000 will be required during the fiscal year. In 1894

the amount appropriated by Congress for this purpose was $13,700, since which time it has been reduced until now the amount is only $8000, a decrease of $5700 over the amount required eleven years ago, notwithstanding that during this period the service has expanded very much and the cost of supplies has increased from 20 to 30 per cent. Many of the rooms in the main building are in need of suitable office equipment, such as carpets, file cases, and other furniture, but it has been impossible to supply the same out of the small amount appropriated, which is barely sufficient to purchase the stationery required for ordinary office use.

PERSONNEL.

CLASSIFIED SERVICE.

Appointments.—During the last fiscal year 95 appointments were made to the classified service, of which number 82 were of persons certified by the Civil Service Commission for positions with salaries ranging from $360 to $1000 per annum; 5 were by transfer from other departments, at salaries from $630 to $1250 per annum, and 8 by reinstatement, at salaries from $360 to $1250 per annum.

Promotions—During the same period 83 promotions were ordered, all by advancement to the next higher grade.

In making these promotions the Secretary of Agriculture has not only recognized efficiency, but length of service as well. The 5 men promoted to the $2000 grade had served from eighteen to thirty-one years; the 4 promoted to $1800, from eight to twenty-seven years; the 1 promoted to $1600, twenty-five years; the 4 to $1500, eight to twenty-two years; the 1 to $1400, five years; the 5 to $1300, eight to eighteen years; the 13 to $1200, two to twenty-three years; the 12 to $1000, two to eight years; the 5 to $900, two to nine years; the 1 to $840, nine months; the 4 to $720, five to eight years; the 2 to $600, seven to eight years; the 24 to $480, one to eight years; and the 2 to $450, two to three years. It will be noted that no employee was promoted until he had served at least nine months in the lower grades; that no employee reached the $1600 grade until he had given eight years of service, while no promotion to $2000 was made until after a service of eighteen years.

Reductions.—During the year 19 reductions were ordered. Fourteen were due to the exigencies of the service (mostly changes of station assignments requested by the employee or necessitated by the public needs) and were without personal prejudice. Two were for laxness in the care and preparation of records, want of system in organizing and directing work, and generally unsatisfactory condition of station; 1 for neglect of duty and intemperance, and 2 for physical disability.

Resignations.—There were 56 resignations, all but two voluntary. Nine were tendered by lower-grade employees who were examined and certified by the Civil Service Commission for higher positions in the Bureau. Of the 2 resignations requested, 1 was for intemperance and neglect of duty, and 1 for excessive absence with and without pay.

Removals.—Seven discharges were made, all for cause, as follows: Intoxication, neglect of duty, and absence without leave, 1; unsatisfactory service, 4; absence without leave, 1; disobedience of orders, 1.

Deaths.—Two deaths were recorded.

UNCLASSIFIED SERVICE.

But 4 appointments to the unclassified service were made during the year, and these were at salaries ranging from $300 to $600 per annum, and but 1 promotion was made, from $600 to $660, after a service of four years. There were 8 resignations, all voluntary, and no reductions.

The removals in the unclassified service numbered 8. One was without prejudice to the employee, his services being no longer needed (and his place remaining unfilled). Four were replaced by classified employees. Two were discharged for unsatisfactory services, and 1 for disobedience of instructions and absence without leave.

EMPLOYEES OF THE BUREAU.

The following shows the number and classes of employees of the Bureau, both those stationed at Washington, D. C., and those stationed outside of the city:

Numerical strength of the Weather Bureau, July 1, 1903.

At Washington, D. C.:		
Classified	162	
Unclassified	18	
		180
Outside of Washington, D. C.:		
Classified	479	
Unclassified	16	
		495
Total commissioned employees		675
Additional employees outside of Washington, D. C.:		
River observers	213	
Storm-warning displaymen	147	
Cotton region observers	140	
Corn and wheat region observers	132	
Rainfall observers	64	
Fruit and wheat region observers	20	
Sugar and rice region observers	9	
Total noncommissioned employees		725
Total paid employees		1,400
Voluntary observers		3,470
Voluntary crop correspondents		13,836
Total numerical strength		18,706

SALARIES.

In the classified grades the highest salary per annum is $3000, the lowest $360, and the average $1036.34. In the unclassified grades the highest salary per annum is $720, the lowest $240, and the average $457.94. The compensation of employees at substations (storm-warning displaymen, river observers, etc.), ranges from 20 cents to 67 cents per day, and their hours of duty from twenty minutes to one hour per day. Public-spirited citizens, cooperating with the Bureau in the capacity of voluntary observers and crop correspondents, serve without compensation other than the receipt of such publications of the Department as may be of interest and value to them.

THE EFFECT OF THE CIVIL SERVICE LAW AND REGULATIONS.

It is a pleasure to report that both the letter and the spirit of the civil service law and regulations have been fully complied with in the Weather Bureau, strict adherence to which has not only facilitated the transaction of business, but has produced a marked and steady improvement in the discipline and efficiency of this branch of the public service. It is rare to-day that any Weather Bureau employee seeks advancement by irregular methods, and this is due to the fact that it is well known to all connected with the Bureau that advancement may be secured solely through merit and efficiency.

Close attention has been given all rules of the Civil Service Commission, as promulgated from time to time, and I am able to report that there is no case in the Bureau of an unclassified employee performing duties that should be done by a classified employee. By reference to the foregoing tabular statement it will be noted that of 675 commissioned employees but 34 are unclassified. It is a significant fact that under the operations of a merit system that covers every employee in the Weather Bureau, the working force in its Central Office has actually decreased, while the volume of business has increased at least 20 per cent. In 1895 there were employed in the Weather Bureau at Washington 198 employees; on July 1, 1903, the number was 180, or a decrease of 18 in the working force.

NEW STATIONS.

There are eight places at which full Weather Bureau me-

teorological stations should be established. At these places observations would be useful in the making of daily forecasts for the country at large, and there are important local interests that would be served; these places are important as distributing centers for daily weather maps and forecasts. I therefore recommend that $20,000 be added to the appropriation for "General expenses" and $20,000 to "Salaries," outside of Washington, which will be needed if these stations be established.

RECAPITULATION OF INCREASES RECOMMENDED.

The increases in appropriations recommended in the foregoing report are as follows:

For improved daily weather maps:	
Material and supplies	$35,000
Salaries	20,000
For extension of river and flood service:	
Material, supplies, and pay of observers	30,000
Salaries at Central Office	5,840
For climate and crop service: Salaries	750
For care of meteorological records: Salaries	4,400
For cables:	
South Manitou to North Manitou, Mich	2,000
Flavel, Oreg., to Fort Canby, Wash.	15,000
Improvement of line between Cape Hatteras and Cape Henry, and its extension to Roanoke Island, N. C.	10,000
For telegraphing observations and forecasts	50,000
For supplies and equipment for Central Office	3,000
For repairs to buildings and grounds at Central Office	3,000
For eight new stations:	
Supplies	20,000
Salaries	20,000
Total increase	218,990

GENERAL CLIMATIC CONDITIONS.

By Mr. W. B. STOCKMAN, District Forecaster, in charge of Division of Meteorological Records.

ATMOSPHERIC PRESSURE.

The distribution of mean barometric pressure for the year 1903 is shown on Chart I; it was highest from the west Gulf States and the central Mississippi Valley eastward to the Atlantic Ocean, the crest, with a mean annual reading of 30.10 inches, overlying southeastern Tennessee. Except in northern New England, the southern Plateau, interior California, and portions of the southern and middle slope and middle Plateau regions the mean annual pressure was 30.00 inches, or higher. The lowest mean readings occurred over the southern Plateau and southeastern California, with the minimum, 29.88 inches, at Yuma, Ariz.

The pressure was slightly below the annual mean in the South Atlantic States, eastern part of the lower Lake region, northern part of the Middle Atlantic States, and in New England, and slightly above the mean in all other districts. The deficiency in mean pressure did not equal —.05 inch at any station, and the maximum excesses were +.05 and +.06 inch in western Kansas, southwestern Nebraska, southeastern Wyoming, west-central Colorado, and central Washington.

TEMPERATURE OF THE AIR.

The distribution of mean annual temperature is shown on Chart IV. The temperature was below the mean in the Gulf States, Florida Peninsula, South Atlantic States generally, Ohio Valley and Tennessee, western lower Lakes, southern upper Lakes, central Mississippi Valley, southern slope region, central Kansas, central and northern Nebraska, the western portions of the Dakotas, Wyoming, western Colorado, Utah, northern Nevada, northern California, southern and central Oregon, and central Washington. Departures of —1.0° to —2.0° occurred in the Gulf States and portions of the Florida Peninsula, South Atlantic States, southern and middle slope and middle Plateau regions. The greatest excesses amounted to +1.0° to +1.6° and occurred in northwestern New York, northeastern lower and eastern upper Michigan, northwestern Minnesota, eastern and central Montana, and southeastern Idaho.

Maximum temperatures of 100°, or higher, occurred during the year in the inland section of southeastern North Carolina, central South Carolina, southeastern Georgia, north-central Florida, northeastern Alabama, southeastern Mississippi, Texas, except the extreme eastern portion and along the Gulf coast, Kansas and Oklahoma generally, south-central Nebraska, southeastern Colorado, eastern and southern New Mexico, Arizona, except the northeastern portion, east-central and southern Utah, southeastern and north-central Nevada, California, except along the coast and in the northeastern and east-central portions, portions of southwestern and northeastern Oregon, southeastern Washington, western Idaho, southeastern Montana, southwestern and south-central North Dakota, western and central South Dakota, and in portions of extreme southern Illinois and southwestern Indiana; of 110°, or higher, in the northwestern portion of the panhandle of Texas, south-central Kansas, western Arizona, southwestern Utah, extreme southern Nevada, and southeastern California; and 120°, or higher, in extreme southeastern California.

During the year freezing temperatures extended as far south as central Florida. Minimum temperatures of zero, or lower, were reported as far south as central New Jersey, northern Delaware, central Maryland, the western parts of Virginia and North Carolina, southern Tennesse, except in the extreme eastern portion, the northern parts of Arkansas, Oklahoma and the panhandle of Texas, central New Mexico, northeastern Arizona and southern Nevada, and to the eastward of central California, central and eastern Oregon, and northeastern Washington; of 10° below zero, or lower, to southern New England, extreme southeastern New York, northern Pennsylvania, and central Ohio and Indiana, southern parts of Illinois and Missouri, southern Kansas, north-central New Mexico, southern Nevada, and a small area in northeastern Arizona, and eastward of eastern California, central and eastern Oregon, and extreme northeastern Washington. In a small area about Lakes Ontario and Erie, western Lake Huron, and eastern Lake Michigan the temperature did not fall so low as 10° below zero. Minimum temperatures of 20° below zero, or lower, occurred as far south as central New England, northeastern New York, western upper Michigan, eastern Wisconsin, extreme northern Illinois, central Iowa, northeastern and extreme western Nebraska, southwestern Colorado, southern and eastern Utah, and in portions of north-central Nevada and southwestern Idaho, and eastward of east-central Nevada, southeastern Idaho, and central Montana; of 30° below, or lower, to northwestern Wisconsin, south-central Minnesota, northern South Dakota and eastern Montana, and in portions of the mountain districts of southwestern Wyoming and central and northwestern Colorado; and 40° below, or lower, to northwestern Minnesota, northern and western North Dakota, and east-central Montana, and in portions of the mountain regions of southwestern Wyoming.

PRECIPITATION.

The distribution of total annual precipitation is shown on Chart V.

Precipitation equalling or exceeding 60 inches for the year occurred in portions of the following States: Southwestern Georgia, northwestern Florida, southwestern Mississippi, east-central Louisiana, along the coasts of northwestern California, Oregon and Washington, in the mountains of East Tennessee, and along the coast of central New Jersey.

TABLE I.—*Annual climatological summary, Weather Bureau stations, 1903.*

Districts and stations.	Elevation of barometer above sea level.	Pressure in inches.†			Temperature of the air, in degrees Fahrenheit.							Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation.			Winds.		Max. velocity.		Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall, inches.‡
		Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Mean maximum.	Minimum.	Mean minimum.	Annual range.			Total, in inches.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Miles, per hour.	Direction.					
New England.					**46.5**	**0.0**							**77**	**38.74**	**— 4.31**									**5.4**	
Eastport	76	29.88	29.96	—.01	41.6	+0.1	85	48	—14	35	99	36	83	36.67	— 8.51	144	101,493	nw.	60	se.	100	126	139	6.0	70.6
Portland, Me	103	29.87	30.00	.00	45.0	—0.7	91	52	— 9	38	100	36	74	37.54	— 4.65	114	83,027	s.	48	se.	141	98	126	5.2	60.4
Concord	298	29.68	30.00	—.02	45.3	—0.7	95	56	—18	35	113	......	......	40.80	+ 0.53	127	48,630	n.	37	w.	131	119	115	5.4	63.2
Northfield	876	29.05	30.02	+.01	41.2	0.0	89	52	—20	30	109	33	75	29.09	— 5.42	132	69,861	s.	46	sw.	88	118	159	6.2	67.0
Boston	125	29.87	30.01	.00	49.5	+0.9	93	57	— 1	42	94	39	71	41.97	— 2.99	123	95,956	w.	48	e.	153	75	137	5.1	42.0
Nantucket	12	30.00	30.01	—.01	49.0	+0.2	87	54	4	44	83	43	82	30.33	—10.40	130	127,276	sw.	50	s.	87	142	136	5.9	38.2
Block Island	26	30.00	30.03	+.01	49.4	+0.3	86	55	5	44	81	42	79	43.61	— 0.58	127	150,764	sw.	72	e.	147	112	106	4.8	23.9
Narragansett	......	......	......		48.2	—0.4	94	57	— 2	40	96	......	......	47.44	— 0.06	116	......	nw.	......	......	192	48	125	......	50.5
New Haven	106	29.91	30.03	.00	49.7	+0.3	94	58	1	41	93	40	73	41.22	— 6.69	124	81,226	n.	60	s.	188	78	99	4.2	37.9
Middle Atlantic States.					**53.5**	**+0.1**							**74**	**43.78**	**+ 0.02**									**5.3**	
Albany	97	29.92	30.03	.00	48.4	+0.2	95	56	— 6	40	101	40	77	34.09	— 3.77	126	64,725	s.	39	w.	117	100	148	5.7	53.0
Binghamton	875	29.09	30.03	—.01	46.6	+0.2	92	56	—12	37	104	......	......	37.12	— 0.16	145	54,794	w.	38	s.	93	122	150	6.0	63.4
New York	314	29.69	30.03	—.01	52.5	+0.8	94	59	2	46	92	42	73	48.60	+ 3.80	130	116,073	nw.	72	nw.	118	109	138	5.5	26.0
Harrisburg	374	29.65	30.05	.00	51.8	+0.3	94	60	1	44	93	41	71	35.90	— 8.16	122	62,141	nw.	53	w.	100	119	146	5.8	36.1
Philadelphia	117	29.92	30.05	.00	54.2	+0.8	96	62	3	46	93	43	71	41.50	+ 1.66	122	88,602	nw.	46	nw.	131	95	139	5.3	16.7
Scranton	805	29.17	30.04	.00	48.8	......	92	58	— 3	40	95	38	70	44.97	......	132	63,889	sw.	41	w.	91	99	175	6.4	31.6
Atlantic City	52	29.99	30.05	+.01	52.5	+0.6	93	59	4	46	89	46	80	61.11	+18.40	119	76,294	sw.	60	se.	123	142	90	4.9	8.7
Cape May	17	30.05	30.07	+.03	53.3	—0.3	91	59	8	48	83	......	......	53.33	+ 9.45	133	74,159	nw.	48	ne.	136	135	94	4.9	4.5
Baltimore	123	29.91	30.04	—.01	55.0	—0.2	97	63	5	47	92	43	68	46.26	+ 2.31	121	65,786	nw.	46	w.	113	114	138	5.6	19.8
Washington	112	29.94	30.06	.00	54.3	—0.4	96	64	3	45	93	45	76	43.55	+ 0.09	125	57,388	nw.	44	sw.	152	94	119	5.0	8.2
Cape Henry	18	30.03	30.05	.00	58.1	—0.6	98	65	16	52	82	......	......	36.50	—15.84	119	118,124	ne.	74	ne.	126	102	137	5.3	T.
Lynchburg	681	29.30	30.05	—.02	56.4	—0.5	96	66	8	47	88	45	72	41.24	— 1.61	111	36,562	nw.	34	nw.	148	129	88	4.7	2.1
Norfolk	91	29.96	30.06	+.01	59.0	0.0	97	67	14	51	83	50	77	46.10	— 5.98	110	79,600	ne.	45	n.	144	108	113	5.0	0.1
Richmond	144	29.91	30.07	+.01	58.0	......	98	67	11	49	87	......	......	47.42	......	121	48,341	n.	33	s.	120	115	130	5.3	2.2
Wytheville	2,293	27.68	30.08	+.01	51.7	......	90	62	— 2	41	92	43	78	36.11	......	124	46,852	w.	36	w.	155	123	87	4.4	16.4
South Atlantic States.					**62.3**	**—0.4**							**76**	**47.60**	**— 4.38**									**5.0**	
Asheville	2,255	27.73	30.07	.00	54.1	—0.5	90	64	5	44	85	45	76	41.18	— 1.27	120	67,170	nw.	44	n.	117	154	94	5.2	0.9
Charlotte	773	29.23	30.07	.00	60.0	+0.1	96	69	17	51	79	48	70	39.49	—12.43	107	57,115	ne.	48	sw.	143	102	120	5.0	T.
Hatteras	11	30.05	30.06	.00	62.2	+0.8	91	67	22	57	69	56	84	48.87	—17.54	116	127,657	sw.	63	n.	144	122	99	4.8	0.0
Raleigh	376	29.67	30.06	.00	59.7	+0.6	99	69	14	50	85	49	73	48.04	+ 1.95	111	54,444	ne.	36	w.	162	104	99	4.6	T.
Wilmington	78	29.96	30.04	—.02	62.6	—0.4	97	71	19	54	78	53	77	48.22	— 6.12	118	71,977	sw.	51	w.	127	135	103	5.0	0.0
Charleston	48	30.02	30.07	.00	65.1	—0.7	98	72	24	58	74	56	77	42.86	—13.88	127	95,353	sw.	55	ne.	88	199	78	5.2	0.0
Columbia	351	29.69	30.07	.00	62.7	—1.0	98	72	19	54	79	52	75	49.82	+ 2.27	122	73,470	sw.	60	sw.	124	130	111	5.2	T.
Augusta	180	29.87	30.06	—.01	63.2	—0.7	98	73	20	54	78	52	74	51.83	+ 3.51	119	53,117	nw.	48	ne.	161	116	88	4.4	0.0
Savannah	65	29.99	30.06	.00	65.8	—0.6	99	74	25	58	74	55	77	53.67	+ 1.76	124	68,685	sw.	48	w.	118	158	89	5.0	0.0
Jacksonville	43	29.99	30.04	—.02	67.8	—1.2	97	76	26	60	71	58	78	52.03	— 2.09	131	83,975	sw.	75	sw.	108	147	110	5.4	0.0
Florida Peninsula.					**73.9**	**—0.2**							**78**	**48.10**	**— 2.85**									**4.7**	
Jupiter	28	30.00	30.03	.00	74.1	+0.5	96	80	36	68	60	66	78	57.26	— 2.31	152	97,748	ne.	78	ne.	102	217	46	5.0	0.0
Key West	22	29.99	30.01	—.01	76.5	—0.6	93	81	51	72	42	68	77	30.36	— 8.12	107	83,873	ne.	45	nw.	135	149	81	4.8	0.0
Tampa	34	30.00	30.03	—.01	71.0	—0.6	95	80	32	62	63	61	79	56.68	+ 1.87	122	55,701	ne.	48	ne.	149	146	70	4.4	0.0
East Gulf States.					**64.4**	**—1.2**							**76**	**49.05**	**— 7.01**									**5.1**	
Atlanta	1,174	28.83	30.07	.00	60.1	—1.1	93	68	12	52	81	50	74	48.66	— 1.72	120	106,462	nw.	60	nw.	105	128	132	5.6	T.
Macon	370	29.67	30.07	+.01	63.0	......	96	72	21	54	75	......	......	45.80	......	124	52,306	nw.	45	sw.	135	71	159	5.5	T.
Pensacola	56	30.00	30.06	+.01	66.4	—1.2	95	73	26	60	69	......	......	58.88	+ 1.79	115	85,712	ne.	48	sw.	154	118	93	4.6	0.0
Mobile	57	30.00	30.06	+.01	65.8	—0.9	96	74	24	58	72	55	76	48.01	—14.60	113	63,154	n.	35	n.	148	118	99	4.8	0.0
Montgomery	223	29.82	30.05	—.01	63.8	—1.4	97	73	19	55	78	54	77	48.99	— 3.73	119	57,077	e.	42	w.	131	114	120	5.2	T.
Meridian	375	29.66	30.06	.00	62.4	—1.6	97	73	15	52	82	......	......	44.59	— 9.88	120	47,590	ne.	34	w.	146	117	102	4.8	T.
Vicksburg	247	29.78	30.04	—.02	64.1	—1.2	94	73	18	55	76	53	75	38.04	—17.62	98	58,838	n.	40	w.	136	118	111	4.9	T.
New Orleans	51	30.00	30.05	+.01	67.9	—0.9	95	76	27	60	68	57	76	57.18	— 3.34	116	72,793	ne.	42	nw.	112	125	128	5.5	0.0
West Gulf States.					**64.5**	**—1.3**							**74**	**38.17**	**— 4.98**									**4.8**	
Shreveport	249	29.79	30.06	+.03	64.0	—1.2	97	73	15	54	82	51	71	29.26	—19.34	101	57,532	se.	34	w.	161	90	114	4.8	2.2
Fort Smith	457	29.55	30.03	.00	59.7	—0.1	95	69	4	50	91	48	71	35.46	— 9.28	95	73,403	e.	50	w.	99	197	69	4.7	15.0
Little Rock	357	29.68	30.06	+.02	60.6	—0.9	94	69	7	52	87	48	70	40.51	—13.12	105	64,636	nw.	40	nw.	158	126	81	4.4	4.3
Corpus Christi	20	30.00	30.02	+.03	69.1	—1.0	92	75	27	63	65	61	79	36.92	+ 6.72	102	91,018	se.	42	e.	137	139	89	4.8	0.0
Fort Worth	670	29.34	30.05	+.04	62.8	......	100	73	12	53	88	......	......	26.70	......	72	93,937	s.	56	nw.	201	103	61	4.0	3.5
Galveston	54	29.96	30.02	—.01	67.8	—2.0	91	73	24	63	67	60	80	52.47	+ 3.79	102	100,003	se.	48	nw.	159	123	83	4.4	0.0
Palestine	510	29.52	30.05	+.03	63.8	—1.4	95	73	14	55	81	53	75	39.48	— 7.03	111	65,741	s.	37	nw.	106	139	120	5.4	2.0
San Antonio	701	29.29	30.01	+.02	66.3	—2.2	99	76	19	57	80	54	71	33.11	+ 3.41	89	62,870	se.	44	nw.	121	129	115	5.1	0.0
Taylor	583	29.42	30.04	+.04	64.5	......	97	75	17	54	80	......	......	38.24	......	97	74,993	s.	50	nw.	103	153	109	5.4	T.
Ohio Valley and Tenn.					**55.6**	**—0.5**							**73**	**37.35**	**— 7.80**									**5.3**	
Chattanooga	762	29.28	30.10	+.03	59.1	—0.8	94	68	6	50	88	47	70	45.17	— 7.73	136	60,139	w.	47	w.	131	133	101	5.1	1.1
Knoxville	1,004	29.01	30.07	.00	57.5	+0.3	95	68	8	47	87	46	74	45.89	— 5.10	124	60,855	sw.	70	nw.	155	104	106	4.7	3.6
Memphis	397	29.65	30.08	+.03	60.6	—0.5	94	68	6	53	88	51	74	36.17	—17.11	101	82,212	nw.	64	nw.	166	96	103	4.6	4.0
Nashville	546	29.50	30.09	+.03	58.5	—0.8	97	68	1	49	96	47	72	43.03	— 7.07	114	59,194	nw.	42	nw.	160	104	101	4.6	3.6
Lexington	989	29.00	30.08	+.02	55.4	—0.7	94	63	— 3	46	97	......	......	30.70	—13.68	135	88,811	sw.	54	s.	128	119	118	5.2	17.4
Louisville	525	29.49	30.08	+.02	56.4	—0.3	98	66	— 1	47	99	44	70	33.69	—12.07	115	69,148	n.	48	w.	135	125	105	5.0	9.2
Evansville	431	29.58	30.06	+.01	56.1	......	96	65	— 3	48	99	......	......	35.51	......	115	62,815	s.	44	sw.	127	131	107	5.0	9.5
Indianapolis	822	29.17	30.06	+.02	51.9	—0.8	94	60	— 9	43	103	42	75	32.46	—10.50	119	90,508	s.	50	sw.	127	124	114	5.2	27.3
Cincinnati	628	29.38	30.07	+.01	54.3	—0.8	96	63	— 1	45	97	43	70	34.69	— 5.18	133	60,376	sw.	42	sw.	115	126	124	5.6	17.9
Columbus	824	29.17	30.05	.00	52.0	—0.1	95	61	— 3	43	98	41	72	28.14	—10.75	122	99,595	sw.	61	sw.	105	127	133	5.8	23.2
Pittsburg	842	29.14	30.05	.00	52.9	0.0	94	61	— 3	44	97	41	69	38.81	+ 2.13	140	52,746	nw.	42	nw.	101	136	128	5.6	26.0
Parkersburg	638	29.39	30.08	+.02	53.9	—0.5	95	64	— 2	44	97	44	74	42.07	+ 1.23	131	48,113	s.	42	nw.	109	123	133	5.7	17.7
Elkins	1,940	28.01	30.07	+.01	49.3	......	90	61	— 5	37	95	41	80	41.84	......	173	36,307	n.	40	w.	64	171	130	6.3	37.9
Lower Lake Region.					**48.3**	**+0.2**							**76**	**35.32**	**— 0.13**									**5.9**	
Buffalo	767	29.18	30.02	.00	48.1	+1.6	89	54	— 3	42	92	40	76	37.95	— 0.09	185	129,572	sw.	72	sw.	52	135	178	6.9	74.1
Oswego	335	29.64	30.01	—.01	46.1	—0.3	87	53	— 8	39	95	39	78	39.65	+ 4.63	162	97,967	s.	44	w.	111	105	149	5.8	87.6
Rochester	523	29.44	30.02	.00	48.0	+1.2	92	56	— 3	40	95	39	75	29.44	— 5.38	149	79,700	sw.	45	w.	87	119	159	6.2	68.3
Syracuse	597	29.37	30.02	—.01	46.9	......	89	54	— 6	39	95	......	......	39.38	......	171	108,242	s.	64	s.	76	145	144	6.2	79.6
Erie	713	29.25	30.03	.00	48.5	—0.2	88	55	— 4	42	92	40	76	35.58	— 5.70	171	96,157	w.	50	nw.	118	90	157	6.1	42.6
Cleveland	762	29.21	30.04	.00	48.9	0.0	89	56	— 5	42	94	40	75	35.41	— 0.88	170	130,701	se.	61	s.	92	128	145	6.0	56.1
Sandusky	629	29.35	30.04	.00	49.6	—0.4	94	57	— 5	42	95	......	......	33.57	— 1.34	137	73,659	sw.	38	w.	164	96	105	4.5	31.2
Toledo	628	29.35	30.04	+.01	49.0	—0.6	94	57	— 7	41	101	39	73	35.08	+ 4.15	119	87,187	sw.	63	w.	131	116	118	5.2	32.3
Detroit	730	29.23	30.04	+.01	48.1	0.0	92	56	— 5	41	97	40	79	35.88	+ 3.55	141	100,750	sw.	50	sw.	94	125	146	5.8	51.3
Upper Lake Region.					43.0	**+5.5**							**76**	**31.59**	**— 0.65**									**5.9**	
Alpena	609	29.34	30.01	.00	42.6	+1.3	93	50	— 9	35	102	36	79	31.54	— 3.54	124	91,987	w.	44	nw.	85	96	184	6.6	41.2
Escanaba	612	29.33	30.01	.00	40.7	+0.5	89	48	—15	33	104	34	81	32.58	+ 0.32	132	72,855	n.	37	n.	123	109	133	5.4	27.4
Houghton	668	29.26	29.99	—.01	40.9	......	94	49	—13	33	107	......	......	39.17	......	165	62,824	e.	44	w.	118	84	163	6.0	104.5
Marquette	734	29.20	30.01	+.01	41.2	+0.7	94	48	—14	35	108	31	70	39.84	+ 7.47	167	95,332	nw.	50	sw.	82	109	174	6.5	93.8
Port Huron	638	29.34	30.04	+.02	45.9	+0.7	90	54	— 5	38	95	38	79	32.91	+ 1.31	129	100,189	sw.	48	w.	98	112	155	6.1	43.3
Sault Ste. Marie	614	29.30	29.98	—.02	40.2	+1.2	87	48	—20	32	107	32	74	29.04	— 0.49	154	74,799	nw.	49	nw.	99	101	165	6.2	45.9
Chicago	823	29.15	30.05	+.02	47.7	—0.6	92	54	—13	41	105	39	76	28.09	— 6.67	116	147,572	sw.	72	sw.	117	132	116	5.4	34.2
Milwaukee	681	29.29	30.04	+.02	46.0	+1.0	91	54	—14	38	105	39	80	33.41	+ 1.35	135	95,029	w.	56	ne.	139	92	134	5.2	40.5
Green Bay	617	29.34	30.02	+.01	43.4	0.0	89	52	—20	35	109	35	75	28.89	— 2.61	131	94,411	sw.	59	nw.	85	106	174	6.4	38.6
Duluth	702	29.24	30.02	+.01	39.1	—0.2	92	47	—24	32	116	30	73	28.01	— 3.00	136	88,221	ne.	56	nw.	121	145	99	5.3	52.4
North Dakota.					**38.9**	**+0.2**							**72**	**21.31**	**+ 2.36**									**4.8**	
Moorhead	935	29.00	30.04	+.03	38.9	+1.3	92	50	—30	28	122	31	80	28.29	+ 4.52	107	91,086	se.	51	sw.	146	101	118	5.0	41.7
Bismarck	1,674	28.23	30.04	+.04	39.9	+0.3	99	51	—41	28	140	27	65	17.96	— 0.42	75	89,793	nw.	63	nw.	187	105	73	4.3	13.2

TABLE I.—*Annual climatological summary, Weather Bureau stations, 1903*—Continued.

Districts and stations.	Elevation of barometer above sea level.	Pressure in inches.†			Temperature of the air, in degrees Fahrenheit.							Mean temperature of the dew-point.	Mean relative humidity, per cent.	Precipitation.			Winds.				Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall, inches.‡
		Actual, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Mean maximum.	Minimum.	Mean minimum.	Annual range.			Total, in inches.	Departure from normal.	Days with .01, or more.	Total movement, miles.	Prevailing direction.	Max. velocity. Miles, per hour.	Max. velocity. Direction.					
North Dakota—Cont'd.																									
Williston	1,875	27.98	29.99	.00	38.0	−0.9	95	50	−46	26	141	28	71	17.69	+ 2.99	97	86,815	se.	66	nw.	138	98	129	5.1	29.0
Upper Miss. Valley.					**49.7**	**−0.1**							**74**	**33.83**	**− 0.51**									**5.2**	
Minneapolis	....	....	....	....	43.1	−1.2	92	52	−24	35	116	....	....	36.19	+ 8.98	110	105,719	nw.	60	nw.	99	134	132	....	38.8
St. Paul	837	29.10	30.02	+.01	43.5	+0.2	90	52	−24	35	114	35	76	37.88	+10.41	118	70,047	nw.	46	nw.	146	92	127	5.2	28.8
La Crosse	714	29.25	30.04	+.02	45.6	−0.4	90	54	−21	37	111	....	....	34.40	+ 3.72	120	68,529	s.	40	n.	124	127	114	5.2	27.6
Davenport	606	29.36	30.02	−.01	49.6	+0.4	95	58	−15	41	110	40	75	35.73	+ 2.01	102	67,615	w.	34	w.	128	113	124	5.2	26.4
Des Moines	861	29.12	30.06	+.04	48.9	+0.4	94	58	−13	39	107	39	74	31.43	− 1.68	109	76,278	sw.	48	sw.	90	150	125	5.9	35.2
Dubuque	698	29.28	30.04	+.02	47.4	−0.2	91	56	−17	38	108	38	74	31.79	− 3.74	126	62,454	nw.	38	nw.	129	102	134	5.6	22.4
Keokuk	614	29.36	30.03	.00	51.4	0.0	96	60	−13	43	109	42	76	33.28	− 1.44	100	67,900	sw.	42	nw.	148	132	85	4.4	27.4
Cairo	356	29.68	30.07	+.02	57.4	−0.3	95	66	− 1	49	96	48	75	32.91	− 9.92	117	74,043	s.	60	n.	111	143	111	5.3	6.1
Springfield, Ill.	644	29.36	30.05	+.01	51.8	−0.5	97	61	−12	42	109	42	75	28.33	− 9.68	102	82,835	nw.	46	nw.	130	109	126	5.2	31.2
Hannibal	534	29.46	30.04	+.01	52.4	−0.1	96	62	−18	43	114	....	....	36.41	+ 3.03	107	80,950	sw.	52	nw.	146	133	86	4.6	38.8
St. Louis	567	29.43	30.04	.00	56.0	+0.4	98	64	− 6	48	104	44	70	33.81	− 7.27	112	87,417	s.	52	w.	138	112	115	5.0	18.3
Missouri Valley.					**49.4**	**0.0**							**72**	**32.25**	**+ 3.48**									**5.0**	
Columbia	784	29.20	30.04	+.01	52.9	−2.1	95	63	−15	43	110	....	....	36.78	+ 0.09	131	70,321	se.	47	nw.	117	100	148	5.7	19.5
Kansas City	963	29.02	30.06	+.02	53.9	+0.7	97	62	− 9	45	106	42	71	39.22	+ 2.88	108	72,918	se.	41	nw.	151	105	109	4.6	25.3
Springfield, Mo.	1,324	28.64	30.05	+.02	54.6	−0.3	93	63	− 3	46	96	45	76	43.52	− 0.53	117	92,001	se.	67	n.	218	65	82	3.8	10.7
Topeka	....	....	....	....	53.1	−0.7	98	63	−10	43	108	....	....	44.14	+10.66	105	81,446	s.	43	nw.	128	141	96	5.0	20.4
Lincoln	1,189	28.74	30.02	+.01	50.0	−0.1	99	60	−13	40	112	39	72	34.66	+ 7.90	106	97,850	s.	76	nw.	150	118	97	4.6	33.0
Omaha	1,105	28.84	30.03	+.01	50.2	+0.6	98	59	−15	41	113	39	72	33.43	+ 1.74	117	81,432	s.	52	nw.	117	132	116	5.4	26.6
Valentine	2,598	27.25	30.00	.00	46.2	−0.1	98	58	−18	34	116	34	70	17.15	− 2.00	81	99,481	nw.	76	sw.	160	108	97	4.4	26.3
Sioux City	1,135	28.78	30.03	+.01	47.0	0.0	93	56	−18	37	111	....	....	41.10	+16.15	103	111,503	nw.	72	nw.	113	114	138	5.6	30.7
Pierre	1,572	28.34	30.03	+.03	46.0	+0.6	105	57	−20	35	125	33	67	19.53	+ 3.76	94	71,695	se.	49	n.	119	138	108	5.2	38.7
Huron	1,306	28.62	30.04	+.03	42.5	+0.2	98	55	−31	30	129	32	74	13.83	− 7.20	80	106,347	nw.	72	nw.	126	119	120	5.3	21.1
Yankton	1,233	28.68	30.02	+.01	46.5	+0.7	95	57	−22	36	117	....	....	31.38	+ 4.56	102	68,772	nw.	50	nw.	146	123	96	4.9	53.3
Northern Slope.					**44.6**	**+0.2**							**68**	**14.76**	**+ 0.36**									**4.6**	
Havre	2,505	27.34	30.01	+.04	42.1	+1.0	96	54	−29	30	125	31	72	16.03	+ 1.94	87	85,799	sw.	60	sw.	147	144	74	4.7	42.1
Miles City	2,371	27.46	29.99	.00	45.6	+1.4	104	57	−30	34	134	38	80	9.98	− 2.73	64	56,906	nw.	54	sw.	204	109	52	3.8	14.6
Helena	4,110	25.81	30.04	+.03	44.0	+0.9	91	54	−16	34	107	27	58	11.36	− 1.82	100	67,072	sw.	48	sw.	131	119	115	5.2	49.3
Kalispell	2,965	26.94	30.03	+.04	42.0	....	90	52	−10	32	100	31	70	14.63	....	118	46,578	w.	37	sw.	134	125	106	5.1	42.2
Rapid City	3,234	26.60	30.00	+.01	45.7	−0.3	100	57	−16	34	116	33	69	21.28	+ 4.57	93	70,071	w.	56	w.	172	103	90	4.3	28.7
Cheyenne	6,088	24.01	30.02	+.05	43.7	−0.7	90	56	−20	32	110	27	59	12.25	+ 0.05	105	93,166	nw.	56	w.	128	138	99	4.9	65.6
Lander	5,372	24.64	30.02	+.02	42.2	−0.2	93	57	−28	27	121	27	64	14.08	+ 0.41	72	32,224	sw.	36	w.	149	151	65	4.3	55.0
North Platte	2,821	27.09	30.04	+.05	48.9	+1.0	98	61	−11	37	109	37	72	18.36	+ 0.09	82	76,761	nw.	49	n.	144	165	56	4.6	30.7
Middle Slope.					**53.2**	**−0.2**							**66**	**22.00**	**− 0.16**									**4.4**	
Denver	5,291	24.72	30.00	+.04	49.8	+0.4	97	62	−10	37	107	31	57	9.50	− 4.99	75	70,798	s.	54	nw.	152	140	73	4.5	45.6
Pueblo	4,685	25.29	29.99	+.04	50.8	−0.3	98	65	−13	36	111	29	53	10.35	− 1.76	73	60,631	nw.	48	nw.	162	154	49	4.1	26.3
Concordia	1,398	28.55	30.03	+.02	52.2	0.0	98	62	−12	42	110	42	76	38.19	+12.39	103	67,281	s.	45	s.	145	133	87	4.6	22.9
Dodge	2,509	27.41	30.03	+.05	53.2	+0.1	105	66	−18	40	123	39	69	15.27	− 4.57	82	103,163	s.	72	s.	170	82	113	4.6	44.0
Wichita	1,358	28.60	30.04	+.03	55.3	−0.1	105	66	− 6	45	111	44	73	31.08	+ 1.47	84	80,077	s.	41	nw.	193	105	67	4.2	15.0
Oklahoma	1,214	28.74	30.02	+.02	58.1	−1.3	101	68	4	48	97	45	68	27.61	− 3.47	80	103,882	s.	48	nw.	164	123	78	4.3	6.8
Southern Slope.					**58.6**	**−0.6**							**64**	**23.40**	**+ 0.16**									**4.4**	
Abilene	1,738	28.21	30.02	+.04	62.1	−1.3	101	72	11	52	90	48	68	26.53	+ 1.51	68	75,837	se.	48	w.	142	113	110	4.7	4.4
Amarillo	3,676	26.26	29.99	+.03	55.0	+0.2	98	67	− 3	43	101	37	61	20.28	− 1.28	65	120,763	s.	60	nw.	195	138	32	4.1	38.6
Southern Plateau.					**59.5**	**−0.4**							**39**	**9.34**	**− 0.91**									**2.8**	
El Paso	3,762	26.17	29.91	+.02	62.6	−0.8	102	76	14	49	88	34	43	11.63	+ 2.30	51	89,791	nw.	73	sw.	201	131	33	3.1	4.4
Santa Fe	7,013	23.27	29.97	+.04	48.7	+0.4	89	60	− 4	38	93	25	46	9.79	− 4.46	75	59,628	se.	46	s.	242	94	29	2.7	21.8
Flagstaff	6,907	23.36	29.94	+.03	45.0	−2.7	92	60	−18	30	110	....	....	25.05	+ 2.79	88	....	sw.	....		170	122	73	3.9	128.3
Phoenix	1,108	28.75	29.90	+.02	69.7	+0.5	111	84	27	55	84	38	38	6.61	− 0.32	32	37,997	e.	48	se.	226	60	39	2.5	0.0
Yuma	141	29.74	29.88	.00	72.0	−0.2	113	86	29	58	84	42	41	0.98	− 1.99	6	54,794	n.	42	s.	310	40	15	1.1	0.0
Independence	3,910	25.98	29.94	+.01	59.1	+0.5	99	71	14	47	85	22	27	1.95	− 3.78	12	69,017	nw.	75	w.	218	81	66	3.4	7.4
Middle Plateau.					**48.7**	**−1.7**							**53**	**8.50**	**− 2.78**									**3.5**	
Carson City	4,720	25.30	30.02	+.03	47.8	−1.6	92	62	−12	33	104	29	56	6.23	− 5.74	29	57,875	sw.	64	w.	230	75	60	2.9	32.4
Winnemucca	4,344	25.63	30.03	+.02	46.6	−2.0	96	61	−21	32	117	29	57	6.53	− 1.95	52	74,968	ne.	61	sw.	216	62	87	3.4	26.6
Modena	5,479	24.63	29.99	+.04	47.0	....	94	62	−17	32	111	22	47	6.93	....	53	87,941	w.	65	sw.	237	81	47	2.8	27.1
Salt Lake City	4,366	25.63	30.02	+.03	50.4	−0.9	98	60	− 4	40	102	29	51	14.62	− 1.57	77	51,314	se.	57	nw.	169	106	90	4.3	40.0
Grand Junction	4,608	25.40	30.02	+.06	50.1	−2.3	99	63	−15	37	114	29	53	6.62	− 1.88	68	43,605	nw.	41	sw.	175	140	50	3.9	23.6
Northern Plateau.					**49.3**	**+0.1**							**63**	**12.69**	**− 2.93**									**5.1**	
Baker City	3,471	26.47	30.08	+.04	45.0	+0.1	96	55	− 2	35	98	29	61	10.57	− 4.58	94	50,835	se.	36	sw.	131	85	149	5.5	38.6
Boise	2,739	27.20	30.08	+.04	50.8	+0.2	104	62	4	40	100	32	58	9.55	− 4.87	80	37,900	nw.	33	sw.	157	97	111	4.8	20.9
Lewiston	757	29.23	30.04	+.01	53.6	+0.3	108	64	16	43	92	....	....	12.97	− 0.87	96	33,567	e.	40	w.	160	94	111	4.7	11.1
Pocatello	4,482	25.50	30.04	+.02	46.4	+1.0	96	58	−12	35	108	30	58	10.79	− 4.48	86	76,183	e.	36	sw.	160	143	62	4.1	58.3
Spokane	1,943	27.99	30.06	+.04	47.5	−0.3	97	57	4	38	93	33	65	16.55	− 1.70	104	53,541	s.	40	sw.	79	86	200	6.7	28.6
Walla Walla	1,000	28.98	30.06	+.02	52.5	−0.7	101	62	13	43	88	42	74	15.70	− 1.07	96	48,188	s.	46	sw.	147	134	84	4.9	14.9
N. Pac. Coast Region.					**50.2**	**0.0**							**80**	**43.73**	**− 8.22**									**6.6**	
North Head	211	29.83	30.06	+.02	50.1	−0.2	96	54	30	46	66	46	88	50.47	−11.80	201	140,089	nw.	90	se.	66	64	235	7.2	5.9
Port Crescent	259	29.77	30.03	+.02	46.2	−0.4	84	52	21	40	63	....	....	41.96	− 4.32	160	43,196	w.	44	ne.	67	162	136	6.2	24.5
Seattle	123	29.94	30.07	+.05	51.2	−0.3	96	58	24	45	72	43	76	34.55	− 1.35	154	59,415	se.	40	se.	96	126	143	5.9	11.3
Takoma	213	29.84	30.07	+.04	50.0	+0.2	97	57	22	43	75	....	....	45.11	+ 0.48	159	49,712	n.	36	sw.	42	98	225	7.4	19.4
Tatoosh Island	86	29.92	30.02	+.02	48.6	+0.2	84	52	29	45	55	45	88	68.88	−23.69	203	142,655	e.	78	e.	68	66	231	7.3	7.8
Portland	154	29.90	30.06	+.01	52.9	+0.4	97	61	24	45	73	43	73	35.62	−11.21	155	48,036	nw.	36	sw.	87	100	178	6.4	4.9
Roseburg	518	29.51	30.07	+.01	52.5	−0.2	101	62	21	43	80	42	75	29.50	− 5.66	134	30,234	nw.	28	w.	113	100	147	5.6	9.1
Mid. Pac. Coast Region.					**56.2**	**−0.2**							**69**	**24.04**	**− 5.36**									**4.2**	
Eureka	62	30.02	30.09	+.02	51.8	+0.4	85	57	28	47	57	46	82	47.90	+ 2.13	117	59,550	n.	46	n.	99	105	161	5.8	T.
Mount Tamalpais	2,375	27.56	30.03	.00	55.7	....	95	62	25	49	70	36	57	27.46	....	68	156,727	nw.	90	nw.	224	89	52	3.0	8.7
Red Bluff	332	29.65	30.00	−.01	61.5	−1.0	108	73	27	50	81	41	57	22.93	− 3.18	61	51,804	se.	36	se.	232	72	61	3.1	3.0
Sacramento	69	29.92	30.00	+.01	59.4	−0.4	102	70	29	49	73	45	67	14.70	− 6.17	51	70,955	se.	40	*	206	82	77	3.5	0.0
San Francisco	155	29.89	30.06	+.04	55.3	−0.5	96	61	37	49	59	48	80	18.33	− 5.38	57	87,879	w.	42	w.	178	108	79	4.0	T.
Point Reyes Light	490	....	....	....	52.8	+0.6	87	57	34	48	53	....	....	16.35	−14.21	56	191,860	nw.	94	nw.	117	97	151	5.6	0.0
S. Pac. Coast Region.					**61.0**	**+0.1**							**68**	**10.34**	**− 4.24**									**3.3**	
Fresno	330	29.62	29.99	+.02	62.2	−0.8	108	75	25	49	83	41	56	6.19	− 2.81	37	41,123	nw.	36	nw.	238	52	75	3.2	0.0
Los Angeles	338	29.62	29.99	+.01	62.2	+0.8	97	73	32	52	65	48	70	14.77	− 2.53	30	43,474	w.	26	sw.	148	168	49	3.9	0.0
San Diego	87	29.87	29.98	.00	61.2	+0.5	85	67	35	55	50	52	77	6.09	− 4.42	33	50,337	nw.	34	nw.	247	65	53	3.2	0.0
San Luis Obispo	201	29.83	30.05	+.03	58.5	−0.2	98	70	26	47	72	45	70	14.31	− 7.21	37	44,102	w.	28	w.	246	64	55	3.0	0.0
West Indies.																									
Havana	57	29.94	30.00	+.02	75.7	−1.1	91	82	55	69	36	....	....	46.57	− 5.14	137	96,028	e.	52	e.	139	172	54	4.6	0.0
San Juan	82	29.89	29.98	.00	78.8	+0.1	94	85	65	73	29	71	79	60.01	+ 5.50	197	89,390	e.	48	se.	120	183	62	4.8	0.0

* Two or more directions or dates. † Pressure reduced to standard gravity and to the mean of 24 hourly observations. ‡ For the snow year, July 1, 1902, to June 30, 1903.

TABLE II.—*Resultant winds from observations at 8 a. m. and 8 p. m., daily, during the year 1903.*

Stations.	Component direction from—				Resultant.	
	N.	S.	E.	W.	Direction from—	Duration.
	Hours.	*Hours.*	*Hours.*	*Hours.*	°	*Hours.*
New England.						
Eastport, Me	218	209	130	331	s. 87 w.	201
Portland, Me	203	265	101	308	s. 74 w.	215
Concord, N. H. †	153	76	102	112	n. 7 w.	78
Northfield, Vt	227	402	91	121	s. 10 w.	178
Boston, Mass	199	185	134	357	n. 86 w.	220
Nantucket, Mass	215	227	147	302	s. 86 w.	156
Block Island, R. I	216	231	151	304	s. 84 w.	150
Narragansett, R. I.*	95	145	85	144	s. 50 w.	77
New Haven, Conn	320	171	133	257	n. 40 w.	194
Middle Atlantic States.						
Albany, N. Y	250	302	106	213	s. 66 w.	121
Binghamton, N. Y. †	124	72	117	126	n. 10 w.	53
New York, N. Y	204	201	168	311	n. 89 w.	143
Harrisburg, Pa	227	174	207	271	n. 50 w.	83
Philadelphia, Pa	252	201	173	271	n. 62 e.	110
Scranton, Pa	261	224	194	256	n. 60 w.	72
Atlantic City, N. J	240	198	151	308	n. 76 w.	160
Cape May, N. J	244	212	167	249	n. 69 w.	88
Baltimore, Md	258	178	171	284	n. 54 w.	136
Washington, D. C	265	230	165	234	n. 63 w.	78
Cape Henry, Va. †	124	119	90	119	n. 80 w.	29
Lynchburg, Va	225	197	197	292	n. 74 w.	99
Norfolk, Va	237	267	225	156	s. 67 e.	75
Richmond, Va	259	255	154	212	n. 86 w.	58
Wytheville, Va	168	147	170	395	n. 85 w.	225
South Atlantic States.						
Asheville, N. C	272	236	183	208	n. 35 w.	44
Charlotte, N. C	221	266	243	182	s. 53 e.	75
Hatteras, N. C	265	191	202	245	n. 30 w.	85
Raleigh, N. C	261	194	188	249	n. 43 w.	91
Wilmington, N. C	246	213	182	268	n. 68 w.	92
Charleston, S. C	231	229	205	216	n. 80 w.	11
Columbia, S. C	197	230	268	213	s. 59 e.	64
Augusta, Ga	230	201	240	227	n. 24 e.	32
Savannah, Ga	216	229	188	236	s. 75 w.	50
Jacksonville, Fla	243	233	238	194	n. 77 e.	45
Florida Peninsula.						
Jupiter, Fla	230	199	299	167	n. 77 e.	135
Key West, Fla	253	143	419	86	n. 72 e.	351
Tampa, Fla	324	118	270	177	n. 24 e.	226
Eastern Gulf States.						
Atlanta, Ga	234	203	214	252	n. 51 w.	49
Macon, Ga. †	161	80	82	114	n. 21 w.	87
Pensacola, Fla. †	175	56	129	87	n. 18 e.	126
Mobile, Ala	311	231	128	188	n. 37 w.	100
Montgomery, Ala	242	191	243	199	n. 41 e.	67
Meridian, Miss. †	134	91	110	104	n. 8 w.	43
Vicksburg, Miss	237	239	255	161	s. 89 e.	94
New Orleans, La	256	238	246	168	n. 77 e.	80
Western Gulf States.						
Shreveport, La	217	253	282	159	s. 74 e.	128
Fort Smith, Ark	181	153	368	163	n. 82 e.	207
Little Rock, Ark	240	237	203	220	n. 80 w.	17
Corpus Christi, Tex	210	294	322	71	s. 72 e.	266
Fort Worth, Tex	196	319	210	160	s. 22 e.	133
Galveston, Tex	194	320	272	110	s. 52 e.	205
Palestine, Tex	223	313	204	140	s. 35 e.	110
San Antonio, Tex	218	266	362	80	s. 80 e.	286
Taylor, Tex. †	131	163	61	62	s. 2 w.	32
Ohio Valley and Tennessee.						
Chattanooga, Tenn	227	215	160	281	n. 84 w.	121
Knoxville, Tenn	263	217	135	291	n. 74 w.	162
Memphis, Tenn	260	252	188	206	n. 66 w.	20
Nashville, Tenn	236	249	179	232	s. 76 w.	55
Lexington, Ky. †	78	158	106	112	s. 4 w.	80
Louisville, Ky	216	278	161	206	s. 36 w.	77
Evansville, Ind. †	118	129	109	81	s. 68 e.	30
Indianapolis, Ind	217	286	155	221	s. 44 w.	95
Cincinnati, Ohio	184	232	245	248	s. 4 w.	48
Columbus, Ohio	181	288	188	244	s. 28 w.	122
Pittsburg, Pa	291	208	132	291	n. 84 w.	162
Parkersburg, W. Va	202	287	170	220	s. 30 w.	98
Elkins, W. Va	242	180	77	319	n. 76 w.	251
Lower Lake Region.						
Buffalo, N. Y	133	239	160	342	s. 60 w.	209
Oswego, N. Y	168	317	137	255	s. 38 w.	190
Rochester, N. Y	131	266	142	358	s. 58 w.	255
Syracuse, N. Y	144	291	117	303	s. 52 w.	237
Erie, Pa	187	256	132	295	s. 67 w.	176
Cleveland, Ohio	177	325	193	216	s. 9 w.	149
Sandusky, Ohio †	73	141	66	156	s. 53 w.	113
Toledo, Ohio	167	258	165	303	s. 57 w.	165
Detroit, Mich	198	222	155	315	s. 81 w.	162
Upper Lake Region.						
Alpena, Mich	202	205	179	315	s. 89 w.	135
Escanaba, Mich	270	235	103	276	n. 79 w.	176
Houghton, Mich. †	98	63	117	147	n. 41 w.	46
Marquette, Mich	246	191	109	339	n. 77 w.	235
Port Huron, Mich	223	229	150	292	s. 88 w.	142
Sault Ste. Marie, Mich	185	187	251	288	s. 87 w.	37
Chicago, Ill	205	237	179	261	s. 69 w.	88
Milwaukee, Wis	234	199	130	313	n. 80 w.	186
Green Bay, Wis	191	299	162	265	s. 43 w.	148
Upper Lake Region—Cont'd.						
Duluth, Minn	313	140	196	294	n. 29 w.	199
North Dakota.						
Moorhead, Minn	266	229	215	230	n. 22 w.	40
Bismarck, N. Dak	330	165	201	192	n. 3 e.	165
Williston, N. Dak	219	221	203	238	s. 87 w.	35
Upper Mississippi Valley.						
Minneapolis, Minn.*	119	110	88	127	n. 77 w.	40
St. Paul, Minn	236	239	215	252	s. 85 w.	37
La Crosse, Wis. †	120	165	48	76	s. 32 w.	53
Davenport, Iowa	178	221	187	281	s. 65 w.	103
Des Moines, Iowa	218	266	166	244	s. 58 w.	92
Dubuque, Iowa	226	260	179	258	s. 66 w.	86
Keokuk, Iowa	215	262	170	256	s. 62 w.	98
Cairo, Ill	241	290	175	190	s. 17 w.	51
Springfield, Ill	204	272	159	257	s. 55 w.	119
Hannibal, Mo. †	101	126	77	143	s. 70 w.	70
St. Louis, Mo	208	292	173	200	s. 18 w.	88
Missouri Valley.						
Columbia, Mo.*	97	143	100	103	s. 4 w.	46
Kansas City, Mo	222	301	221	166	s. 35 e.	96
Springfield, Mo	215	303	228	166	s. 35 e.	108
Topeka, Kans.*	118	152	89	66	s. 34 e.	41
Lincoln, Nebr	261	292	173	151	s. 35 e.	38
Omaha, Nebr	269	298	137	154	s. 30 w.	34
Valentine, Nebr	272	193	164	257	n. 50 w.	123
Sioux City, Iowa †	136	137	99	86	s. 86 e.	13
Pierre, S. Dak	248	188	300	154	n. 68 e.	158
Huron, S. Dak	279	236	220	174	n. 47 e.	63
Yankton, S. Dak. †	107	97	107	138	n. 72 w.	33
Northern Slope.						
Havre, Mont	174	154	196	368	n. 83 w.	173
Miles City, Mont	226	232	163	251	s. 86 w.	88
Helena, Mont	164	246	69	436	s. 84 w.	373
Kalispell, Mont	95	190	111	456	s. 75 w.	357
Rapid City, S. Dak	254	139	148	341	n. 59 w.	224
Cheyenne, Wyo	284	168	87	344	n. 66 w.	282
Lander, Wyo	181	272	152	285	s. 56 w.	160
North Platte, Nebr	191	238	183	278	s. 64 w.	106
Middle Slope.						
Denver, Colo	231	304	154	180	s. 20 w.	77
Pueblo, Colo	256	156	255	245	n. 2 e.	100
Concordia, Kans	217	303	183	145	s. 24 e.	94
Dodge, Kans	233	269	217	165	s. 55 e.	63
Wichita, Kans	243	315	222	97	s. 61 e.	144
Oklahoma, Okla	231	327	184	109	n. 87 e.	75
Southern Slope.						
Abilene, Tex	183	358	253	111	s. 38 e.	228
Amarillo, Tex	184	363	162	189	s. 8 w.	182
Southern Plateau.						
El Paso, Tex	230	84	270	311	n. 16 w.	153
Santa Fe, N. Mex	232	257	274	158	s. 78 e.	118
Flagstaff, Ariz	187	203	164	346	s. 85 w.	183
Phoenix, Ariz	153	116	321	256	n. 60 e.	75
Yuma, Ariz	254	218	154	236	n. 66 w.	90
Independence, Cal	228	228	156	308	w.	152
Middle Plateau.						
Carson City, Nev	155	255	107	352	s. 68 w.	265
Winnemucca, Nev	270	172	221	275	s. 29 w.	113
Modena, Utah	114	192	155	411	s. 73 w.	268
Salt Lake City, Utah	214	249	282	183	s. 71 e.	105
Grand Junction, Colo	202	194	280	243	n. 78 e.	38
Northern Plateau.						
Baker City, Oreg	199	354	203	204	s.	155
Boise, Idaho	193	212	185	314	s. 81 w.	132
Lewiston, Idaho †	31	90	213	74	s. 67 e.	151
Pocatello, Idaho	33	236	337	242	s. 88 e.	95
Spokane, Wash	182	275	221	198	s. 14 e.	96
Walla Walla, Wash	84	431	152	185	s. 5 w.	348
North Pacific Coast Region.						
North Head, Wash	251	225	206	237	n. 50 w.	40
Port Crescent, Wash*	29	69	118	205	s. 66 w.	96
Seattle, Wash	208	266	269	167	s. 60 e.	117
Tacoma, Wash	256	264	86	265	s. 87 w.	179
Tatoosh Island, Wash	88	272	250	248	s. 1 e.	184
Portland, Oreg	226	241	156	300	s. 84 w.	145
Roseburg, Oreg	324	136	218	223	n. 2 w.	188
Middle Pacific Coast Region.						
Eureka, Cal	286	226	142	221	n. 52 w.	99
Mount Tamalpais, Cal	327	125	96	382	n. 55 w.	349
Red Bluff, Cal	322	245	217	100	n. 57 e.	140
Sacramento, Cal	188	369	230	114	s. 33 e.	215
San Francisco, Cal	141	144	63	480	s. 89 w.	417
Point Reyes Light, Cal*	200	58	28	192	n. 24 w.	156
South Pacific Coast Region.						
Fresno, Cal	354	91	107	395	n. 48 w.	390
Los Angeles, Cal	164	167	179	260	s. 88 w.	81
San Diego, Cal	313	143	133	333	n. 50 w.	262
San Luis Obispo, Cal	239	170	14	319	n. 77 w.	310
West Indies						
Grand Turk, W. I. †	58	76	273	15	s. 86 e.	259
Hamilton, Bermuda	212	219	185	246	s. 84 w.	62
Havana, Cuba †	52	55	273	22	s. 89 e.	251
San Juan, Porto Rico	58	294	472	45	s. 62 e.	488

* From observations at 8 p. m. only. † From observations at 8 a. m. only.

TABLE III.—*Total number of days with thunderstorms at selected stations, 1903.*

State and station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Alabama.													
Mobile	1	3	1	0	4	8	10	14	2	1	2	2	48
Montgomery	1	3	1	6	4	7	12	12	1	1	2	0	50
Scottsboro	0	0	0	0	0	11	13	14	0	1	0	0	39
Arizona.													
Flagstaff	0	0	0	2	2	9	6	9	3	1	0	0	32
Fort Defiance	0	0	0	0	1	0	0	7	0	0	0	0	8
Phoenix	0	0	2	1	2	4	6	7	10	0	0	0	32
Taylor	1	0	0	0	3	9	4	5	2	0	0	0	24
Yuma	0	1	0	0	0	0	0	0	1	0	0	0	2
Arkansas.													
Blanchard	3	8	5	1	1	0	10	7	2	0	0	1	38
Little Rock	3	0	6	6	5	5	11	9	5	1	1	1	53
Pocahontas	1	1	4	4	6	0	6	3	1	2	0	1	29
Fort Smith	2	3	4	6	12	5	8	12	4	6	2	1	65
California.													
Eureka	2	1	0	0	0	0	0	0	0	0	0	0	3
Fresno	0	0	1	0	0	1	0	0	0	0	0	0	2
Independence	0	0	0	0	3	0	0	0	1	0	0	0	4
Los Angeles	0	0	0	1	0	0	0	0	1	0	0	0	2
Mount Tamalpais	0	0	0	0	0	0	0	0	0	0	0	0	0
Red Bluff	0	0	0	0	1	0	0	0	0	1	0	0	2
Sacramento	0	0	0	0	0	0	0	0	0	0	0	0	0
San Diego	0	0	0	0	0	0	0	1	0	0	0	0	1
San Francisco	0	1	0	0	0	0	0	0	0	0	1	0	2
San Luis Obispo	0	0	1	0	1	1	0	0	0	0	0	0	3
Colorado.													
Denver	0	0	0	0	3	9	15	12	3	0	0	0	42
Durango	0	0	0	2	0	4	3	6	0	0	0	0	15
Grand Junction	0	0	1	2	1	8	12	6	7	1	0	0	38
Pueblo	0	0	0	2	5	13	12	13	2	1	0	0	48
Connecticut.													
Hartford	0	0	0	0	1	2	8	0	2	0	0	0	13
New Haven	0	1	0	0	2	4	8	2	3	0	0	0	20
District of Columbia.													
Washington	0	0	1	1	5	7	9	9	5	0	0	0	37
Florida.													
Jacksonville	2	5	3	3	8	20	17	25	7	2	3	0	95
Jupiter	0	1	6	1	6	17	13	15	8	0	1	0	68
Key West	1	1	3	0	1	3	4	6	8	1	0	1	29
Merritt Island	4	0	4	2	7	22	25	31	18	2	0	2	117
Myers	1	1	12	2	5	1	31	31	10	1	0	1	96
Pensacola	2	3	2	0	4	9	11	17	4	1	6	1	60
Tampa	4	1	8	3	7	15	26	22	7	0	2	1	96
Georgia.													
Atlanta	0	2	5	4	8	13	17	14	2	1	3	0	69
Augusta	0	1	2	3	5	9	7	9	1	0	1	1	39
Clayton	1	2	2	1	3	6	5	7	2	0	0	1	30
Macon	0	2	1	5	4	10	11	14	0	0	2	1	50
Savannah	0	1	1	2	4	18	11	19	5	1	1	0	63
Idaho.													
Boise	0	0	2	0	0	7	2	0	2	1	0	0	14
Chesterfield	0	0	1	4	0	6	2	2	0	0	0	0	15
Lewiston	0	0	2	0	0	7	4	1	0	0	0	0	14
Murray	0	0	1	0	0	0	3	6	2	0	0	0	12
Ola	0	0	2	0	0	2	3	0	0	2	0	0	9
Pocatello	0	0	0	1	1	2	3	3	1	0	0	0	11
Illinois.													
Cairo	0	0	4	7	11	4	12	14	4	2	3	1	62
Chicago	0	0	2	6	6	1	9	9	6	2	1	0	42
Cisne	0	0	0	4	5	3	3	6	0	0	0	0	21
Galva	0	0	0	2	4	3	4	3	2	3	0	0	21
Rantoul	0	0	2	5	8	9	8	3	3	5	2	0	45
Springfield	0	0	3	6	8	4	3	7	8	3	2	0	44
Winnebago	0	0	3	4	7	4	6	4	5	4	2	0	39
Indiana.													
Butlerville	0	0	3	5	6	9	4	5	2	2	1	0	37
Cambridge City	0	0	1	4	9	6	5	7	6	4	2	0	44
Evansville	0	0	3	6	7	7	8	7	1	2	3	0	44
Huntington	0	0	1	2	7	4	8	8	2	5	2	0	39
Indianapolis	0	0	1	3	6	3	6	9	2	4	2	0	36
Seymour	0	0	2	6	5	2	5	4	3	4	3	0	34
Iowa.													
Davenport	0	0	3	3	12	2	11	7	7	3	1	0	49
Des Moines	0	0	2	4	13	5	7	10	6	2	0	0	49
Dubuque	0	0	3	5	12	3	9	9	8	2	0	0	51
Keokuk	0	0	2	4	9	4	6	7	9	4	2	0	47
Sioux City	0	0	2	6	9	7	8	12	6	3	0	0	53
Kansas.													
Concordia	0	1	2	1	13	6	9	9	2	1	1	0	45
Dodge	0	0	2	3	8	6	11	13	2	4	0	0	49
Topeka	0	0	1	6	11	7	9	12	8	4	1	1	60
Wichita	0	1	2	7	9	4	6	9	4	6	0	1	49
Kentucky.													
Lexington	0	0	3	4	6	6	11	5	2	2	1	0	40
Louisville	2	0	2	4	8	6	10	8	2	3	1	0	46
Louisiana.													
Grand Coteau	0	3	3	1	3	3	6	2	0	0	0	0	21
New Orleans	4	6	5	1	8	8	17	20	2	0	1	2	74
Shreveport	3	4	3	1	1	6	11	6	3	0	0	0	38
Maine.													
Eastport	0	0	0	0	2	0	4	2	3	1	0	0	12
Farmington	0	0	0	0	2	0	6	1	2	0	0	0	11
Orono	0	0	0	0	0	0	5	1	2	2	0	0	10
Portland	0	0	0	0	1	0	6	1	2	1	0	0	11
Maryland.													
Baltimore	0	1	1	2	6	8	7	3	3	0	0	0	31
Grantsville	0	0	0	2	0	7	14	10	7	0	0	0	40
Princess Anne	0	0	2	2	6	4	6	3	3	0	1	0	27
Massachusetts.													
Boston	1	0	0	0	2	0	8	0	2	1	0	0	14
Monson	0	0	0	0	1	0	5	0	3	0	0	0	9
Nantucket	0	0	0	0	2	0	3	3	1	0	1	1	11

TABLE III.—*Total number of days with thunderstorms, etc.*—Continued.

State and station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Massachusetts—Con.													
New Bedford	0	0	0	0	3	0	2	0	1	0	0	0	6
Williamstown	0	0	0	0	1	3	2	1	1	0	0	0	8
Michigan.													
Alpena	0	0	2	1	3	1	7	6	4	3	0	0	27
Detroit	0	0	2	3	7	5	9	6	5	4	1	0	42
Escanaba	0	0	1	1	6	2	8	9	5	1	0	0	33
Grand Rapids	0	0	0	0	0	0	8	7	6	2	2	0	25
Houghton	0	0	1	0	3	1	4	4	2	3	0	0	18
Marquette	0	0	2	1	7	3	4	5	1	1	0	0	24
Port Huron	1	0	2	0	5	4	9	4	3	4	0	0	32
Sault Ste. Marie	0	0	2	0	2	0	7	6	3	3	0	0	23
Minnesota.													
Collegeville	0	0	2	1	4	3	5	2	3	2	0	0	22
Duluth	0	0	2	0	5	4	10	5	2	2	0	0	30
Minneapolis	0	0	1	5	8	2	5	5	4	2	0	0	32
Moorhead	0	0	0	1	5	1	6	7	4	3	0	0	27
Rolling Green	0	0	1	2	7	1	3	0	2	1	0	0	17
St. Paul	0	0	2	2	5	3	6	6	4	2	0	0	30
Mississippi.													
Biloxi	2	2	1	0	3	3	10	14	1	1	2	0	39
Meridian	1	4	0	4	3	7	13	13	1	0	3	0	49
Vicksburg	2	7	4	0	2	7	14	17	3	2	2	1	61
Water Valley	1	2	2	5	6	3	7	3	0	1	3	0	33
Missouri.													
Columbia	0	2	2	7	11	10	9	14	9	4	2	0	70
Hannibal	0	1	2	3	7	6	5	5	7	2	3	0	41
Kansas City	0	2	3	6	16	5	8	12	6	4	3	1	66
St. Louis	0	1	1	4	9	6	7	10	4	2	1	0	45
Springfield	0	1	4	8	11	10	12	9	6	4	1	2	68
Montana.													
Havre	0	0	0	0	1	3	7	11	1	0	0	0	22
Helena	0	0	1	1	2	6	16	6	1	1	0	0	34
Kalispell	0	0	0	0	1	2	8	2	1	0	0	0	14
Miles City	0	0	0	0	1	4	8	6	0	0	0	0	19
Ovando	0	0	0	0	1	3	2	1	1	0	0	0	8
Parrot	0	0	0	2	1	2	2	3	1	0	0	0	11
Nebraska.													
Lincoln	0	0	1	5	13	7	12	12	6	4	2	0	62
North Platte	0	0	1	1	5	8	11	8	4	1	0	0	39
Omaha	0	0	0	3	12	8	11	9	5	3	2	0	53
Valentine	0	0	2	2	5	7	13	6	3	0	0	0	38
Nevada.													
Belmont	0	0	0	0	0	0	0	0	4	0	0	0	4
Carson City	0	0	0	0	0	1	0	0	0	0	0	0	1
Winnemucca	0	0	0	1	0	5	0	0	0	0	1	0	7
New Hampshire.													
Concord	0	1	0	0	2	2	6	1	1	0	0	0	13
Bethlehem	0	0	0	0	0	2	2	0	2	1	0	0	7
Nashua	0	0	0	0	0	2	5	1	2	0	0	0	10
New Jersey.													
Atlantic City	0	0	2	0	0	2	9	3	2	1	1	0	20
Cape May	0	0	2	1	3	4	11	4	2	3	1	0	31
Somerville	0	1	0	0	1	0	11	3	3	2	0	0	21
New Mexico.													
Albert	0	1	0	2	3	4	4	6	2	0	0	0	22
Arbela	0	0	0	0	0	1	0	0	0	0	0	0	1
Santa Fe	0	0	1	3	4	9	18	15	2	0	0	0	52
New York.													
Albany	0	0	0	0	2	4	8	4	2	2	0	0	22
Binghamton	0	0	0	1	2	5	7	5	2	1	0	0	23
Buffalo	1	0	0	1	2	2	10	3	1	2	1	0	23
New York	0	1	0	0	1	7	8	3	2	1	0	0	23
Oswego	1	1	0	1	0	7	8	5	3	2	0	0	28
Rochester	0	0	0	1	1	6	6	5	2	3	0	0	24
South Canistoe	0	1	0	3	2	3	7	6	2	4	1	0	29
Syracuse	1	0	0	3	1	6	8	5	3	0	0	0	27
North Carolina.													
Asheville	0	0	2	6	10	11	14	8	4	0	1	0	56
Brewers	0	2	2	6	10	11	14	8	4	0	1	0	58
Charlotte	0	2	5	5	4	7	7	14	1	1	1	0	47
Hatteras	0	0	1	2	2	2	7	8	5	1	2	0	30
Raleigh	0	0	3	4	6	9	10	11	2	0	1	0	46
Wilmington	2	0	1	7	3	10	7	12	1	0	1	0	44
North Dakota.													
Amenia	0	0	0	1	2	0	4	5	2	1	0	0	15
Bismarck	0	0	0	2	4	5	6	5	2	0	0	0	24
Williston	0	0	0	1	5	4	12	9	2	1	0	0	34
Ohio.													
Cincinnati	0	0	3	3	7	6	4	8	3	3	2	0	39
Cleveland	0	1	2	2	10	6	13	6	2	3	1	0	46
Columbus	0	0	2	2	6	8	6	4	2	3	3	0	36
Sandusky	0	1	1	2	4	4	6	5	3	2	1	0	29
Toledo	0	0	2	1	5	7	9	4	4	3	3	0	38
Oklahoma.													
Oklahoma	1	1	2	5	11	6	3	9	7	6	2	1	54
Perry	0	3	3	1	3	2	1	3	3	4	0	0	23
Oregon.													
Astoria	0	0	0	0	0	2	0	0	0	0	1	1	4
Baker City	0	0	0	0	0	7	1	0	1	0	0	0	9
Portland	0	0	0	0	0	3	0	1	0	0	0	0	4
Roseburg	0	0	0	0	0	0	0	0	0	0	0	0	0
Pennsylvania.													
Erie	1	0	1	2	6	5	9	5	2	4	1	0	36
Harrisburg	0	0	1	1	5	8	7	6	2	1	0	0	31
Philadelphia	0	1	1	2	5	4	9	6	2	1	0	0	31
Pittsburg	1	0	2	1	6	6	10	8	3	1	1	0	39
Scranton	0	0	0	1	4	5	8	3	2	0	0	0	23
Wellsboro	0	0	0	2	3	7	6	3	1	2	1	0	25
Rhode Island.													
Block Island	0	0	0	0	1	2	4	3	2	1	0	1	14
Narragansett	0	0	0	0	1	2	6	1	2	1	0	1	14
South Carolina.													
Charleston	2	1	1	4	3	15	11	17	6	0	2	0	62
Columbia	0	1	3	6	6	11	7	13	2	1	1	0	51

TABLE III.—*Total number of days with thunderstorms, etc.*—Continued.

State and station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
South Dakota.													
Huron	0	0	1	1	6	6	13	9	6	0	0	0	42
Pierre	0	0	0	1	5	5	10	12	2	2	0	0	37
Rapid City	0	0	0	0	5	4	8	11	2	0	0	0	30
Yankton	0	0	3	3	10	9	5	9	7	2	0	0	48
Tennessee.													
Chattanooga	0	3	7	4	5	10	19	15	1	2	3	0	69
Knoxville	0	0	3	3	5	9	12	12	2	0	3	0	49
Memphis	1	0	3	6	7	4	6	6	0	0	2	0	35
Nashville	0	3	2	6	6	8	9	9	0	3	3	0	49
Texas.													
Abilene	0	1	2	3	4	8	6	5	4	2	1	0	36
Amarillo	0	1	1	1	2	7	7	11	1	1	0	0	32
Corpus Christi	1	2	3	1	6	5	7	8	2	4	4	0	43
El Paso	0	1	0	2	2	2	4	10	4	0	0	0	25
Fort Worth	0	3	2	2	5	8	5	8	4	4	0	0	41
Galveston	2	5	5	2	5	4	10	15	1	4	1	1	55
Palestine	1	3	4	1	5	6	8	10	4	5	0	0	47
San Antonio	0	5	3	2	7	8	9	6	3	4	0	0	47
Taylor	1	4	2	1	3	7	8	1	1	1	1	0	30
Utah.													
Grover	0	0	0	0	2	2	4	1	2	1	0	0	12
Modena	0	0	0	0	2	7	4	11	4	1	0	0	29
Salt Lake City	0	0	3	2	5	6	3	6	3	0	0	0	28
Vermont.													
Northfield	0	1	0	0	1	6	6	4	2	0	0	0	20
Jacksonville	0	1	0	0	3	7	8	3	2	0	0	0	24
Virginia.													
Cape Henry	0	0	6	4	5	10	7	7	2	1	1	0	43
Dale Enterprise	0	0	1	2	11	7	7	8	3	0	2	0	41
Lynchburg	0	0	1	2	4	7	10	4	5	1	1	0	35
Norfolk	0	0	5	3	1	5	7	7	2	1	1	0	32
Richmond	0	0	3	2	6	8	7	8	2	0	1	0	37
Wytheville	0	2	1	2	5	7	12	9	5	0	0	0	43
Washington.													
North Head	0	0	0	0	0	2	0	0	0	0	1	0	3
Port Crescent	0	0	0	0	0	1	0	0	0	0	0	0	1
Seattle	0	0	0	1	0	1	1	1	0	0	0	0	4
Spokane	0	0	1	0	1	1	6	2	0	0	0	0	11
Tacoma	0	0	0	0	0	2	0	1	1	0	0	0	4
Tattoosh Island	0	0	0	0	0	1	0	0	0	0	5	1	7
Walla Walla	0	0	1	0	1	4	4	0	1	0	0	0	11
West Virginia.													
Elkins	0	0	0	0	13	5	5	6	0	2	0	0	31
Parkersburg	0	0	3	3	12	6	5	6	3	3	1	0	42
Upper Tract	0	0	0	1	9	8	7	6	3	0	1	0	35
Wisconsin.													
Green Bay	0	0	2	2	7	2	8	6	6	3	0	0	36
La Crosse	0	0	3	5	9	4	5	7	5	2	0	0	40
Milwaukee	1	0	4	4	9	5	7	5	7	3	1	0	46
Wyoming.													
Cheyenne	0	0	0	5	5	8	11	17	3	0	0	0	49
Fourbear	0	0	0	3	2	6	6	3	2	0	0	0	22
Lander	0	0	0	1	0	4	2	6	1	1	0	0	15

TABLE IV.—*Number of days on which thunderstorms were reported, 1903.*

States.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Alabama	3	12	10	10	11	21	22	29	8	6	6	3	141
Arizona	0	3	5	3	13	11	24	28	22	2	0	0	111
Arkansas	6	10	11	15	24	16	28	23	13	10	7	4	167
California	3	4	13	8	10	9	4	13	11	1	6	1	83
Colorado	0	1	8	20	21	28	30	28	18	10	0	0	164
Connecticut	1	3	3	0	9	11	19	11	8	2	0	1	68
Delaware	0	1	2	3	8	6	11	6	4	2	1	0	44
Dist. of Columbia	0	0	1	1	5	7	9	9	5	0	0	0	37
Florida	14	13	19	10	19	28	31	31	25	9	12	4	215
Georgia	3	10	15	7	15	26	26	30	10	7	11	1	161
Idaho	0	0	9	7	12	21	15	15	10	6	0	0	95
Illinois	0	1	10	20	24	21	25	21	18	8	9	4	161
Indiana	1	3	10	16	19	19	23	21	15	15	9	0	151
Indian Territory	2	1	4	4	16	8	6	12	8	7	2	3	73
Iowa	0	2	12	16	26	22	26	26	16	17	7	0	149
Kansas	1	3	11	19	27	23	20	25	22	16	7	5	182
Kentucky	2	6	8	13	14	20	21	19	6	8	7	0	124
Louisiana	9	21	17	11	18	19	4	30	8	6	4	4	151
Maine	0	1	0	4	6	7	23	8	3	3	3	0	58
Maryland	0	3	10	13	17	22	20	22	9	4	2	0	122
Massachusetts	1	1	1	3	6	9	21	9	9	3	1	2	66
Michigan	4	1	10	11	22	20	23	22	24	14	6	0	157
Minnesota	0	0	6	13	13	16	20	22	17	7	0	0	122
Mississippi	8	14	15	9	13	16	25	28	6	11	8	3	156
Missouri	2	6	10	23	27	20	25	24	18	14	10	3	182
Montana	0	0	3	9	16	20	29	26	5	5	1	0	114
Nebraska	0	2	7	16	28	22	31	29	20	11	4	0	170
Nevada	1	0	2	2	9	12	3	6	8	1	1	0	45
New Hampshire	1	4	0	0	6	12	15	11	6	2	0	0	57
New Jersey	0	1	7	6	15	13	20	18	8	7	3	1	99
New Mexico	0	0	2	8	11	18	19	27	5	2	0	1	93
New York	3	6	8	6	13	22	24	24	16	18	2	2	144
North Carolina	5	4	14	16	22	27	28	26	14	7	8	2	173
North Dakota	0	0	1	8	13	15	15	24	7	6	0	0	89
Ohio	3	6	8	11	18	24	25	24	14	11	5	1	150
Oklahoma	2	2	6	13	24	14	14	16	13	9	3	3	119
Oregon	6	0	6	3	4	21	12	7	2	4	12	1	78
Pennsylvania	2	5	6	8	19	23	23	22	7	10	3	0	128
Rhode Island	1	0	2	1	2	4	11	5	3	1	0	1	31
South Carolina	5	6	11	12	20	25	28	26	14	9	6	1	163
South Dakota	0	0	10	12	23	22	29	26	15	8	0	0	145
Tennessee	4	8	15	13	18	22	26	24	9	8	11	3	161
Texas	5	17	13	16	21	25	24	30	18	16	6	4	195
Utah	1	0	9	8	14	19	17	22	16	3	0	0	109
Vermont	0	2	1	0	8	12	17	10	4	0	0	0	54
Virginia	2	4	10	9	18	22	22	24	11	7	4	1	134
Washington	0	1	5	4	6	15	17	11	6	4	7	3	79
West Virginia	2	4	9	12	18	19	22	21	8	9	5	0	129
Wisconsin	1	2	8	13	26	21	21	22	16	9	2	0	141
Wyoming	1	1	5	8	13	21	22	22	7	2	0	0	102
Total	105	195	388	473	788	896	997	1015	565	357	201	62	6042

TABLE V.—*Number of days on which auroras were reported, 1903.*

States.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Alabama	0	0	0	0	0	0	0	0	0	0	0	0	0
Arizona	0	0	0	0	0	0	0	0	1	1	1	1	4
Arkansas	0	0	0	0	0	0	0	0	0	0	0	0	0
California	0	0	0	0	0	0	0	0	0	1	0	0	1
Colorado	1	4	0	0	0	0	0	0	0	2	0	0	7
Connecticut	0	0	0	0	0	0	0	2	0	3	0	0	5
Delaware	0	0	0	0	0	0	0	0	0	0	0	0	0
Dist. of Columbia	0	0	0	0	0	0	0	0	0	1	0	0	1
Florida	0	0	0	0	0	0	0	0	0	0	0	0	0
Georgia	0	0	0	0	0	0	0	0	0	1	0	1	2
Idaho	0	0	0	0	0	0	0	1	0	1	0	0	2
Illinois	2	1	0	2	1	0	0	3	3	5	2	1	20
Indiana	0	0	0	0	0	1	1	2	0	1	0	0	5
Indian Territory	0	0	0	0	0	0	0	1	1	0	0	0	2
Iowa	1	0	0	0	0	1	0	1	1	0	1	0	5
Kansas	0	0	1	0	0	0	0	3	0	0	0	0	4
Kentucky	0	0	1	0	0	0	0	0	0	0	3	1	5
Louisiana	0	0	0	0	0	0	0	0	0	0	0	0	0
Maine	0	0	0	1	1	0	2	2	4	4	7	1	22
Maryland	1	1	4	0	0	0	0	1	0	1	1	4	13
Massachusetts	0	0	0	1	0	0	0	2	2	4	5	3	17
Michigan	0	0	0	1	1	0	0	1	4	10	5	1	23
Minnesota	0	0	1	0	0	0	0	2	3	3	6	1	16
Mississippi	0	0	0	0	0	0	0	0	0	0	0	0	0
Missouri	0	0	0	2	0	0	0	2	0	0	2	0	6
Montana	1	2	1	1	0	0	0	3	2	5	6	1	22
Nebraska	0	0	0	0	0	0	0	0	0	1	4	3	8
Nevada	0	0	0	0	0	0	0	0	0	0	0	0	0
New Hampshire	0	0	0	0	1	1	2	1	5	2	4	3	19
New Jersey	0	0	0	0	0	0	1	1	0	3	0	0	5
New Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0
New York	0	0	1	2	0	1	2	2	5	8	1	1	23
North Carolina	0	0	0	0	0	0	0	0	0	0	0	0	0
North Dakota	2	3	1	0	0	1	0	5	6	7	11	6	42
Ohio	3	0	0	0	0	0	0	1	0	3	2	0	9
Oklahoma	0	0	1	1	0	0	0	0	1	0	0	0	3
Oregon	0	0	0	0	0	0	0	0	0	1	0	0	1
Pennsylvania	0	0	1	0	0	0	0	2	0	0	5	1	9
Rhode Island	0	0	0	0	0	0	1	1	0	1	1	0	4
South Carolina	0	0	0	0	0	0	0	0	0	0	0	0	0
South Dakota	1	4	0	1	0	1	0	1	4	2	11	6	31
Tennessee	2	0	0	0	0	0	0	0	0	1	0	1	4
Texas	0	0	0	0	0	0	0	0	0	0	0	1	1
Utah	0	0	0	1	0	0	0	0	0	1	2	0	4
Vermont	0	0	0	0	0	0	2	1	3	3	3	0	12
Virginia	0	1	0	0	0	0	0	0	0	2	0	0	3
Washington	0	0	0	0	0	1	0	0	0	3	0	0	4
West Virginia	1	1	0	0	0	0	1	0	0	1	0	0	4
Wisconsin	0	0	0	0	0	0	0	1	3	6	2	1	13
Wyoming	0	0	2	0	0	0	0	0	0	1	2	0	5
Total	15	17	14	13	4	7	12	42	48	89	87	38	386

TABLE VI.—*Annual climatological summary, Canadian stations, 1903.*

Stations.	Pressure.*			Temperature.				Precipitation.		Total depth of snowfall.†
	Mean not reduced.	Mean reduced.	Departure from normal.	Mean.	Departure from normal.	Mean maximum.	Mean minimum.	Total.	Departure from normal.	
	Ins.	*Ins.*	*Ins.*	°	°	°	°	*Ins.*	*Ins.*	*Ins.*
St. Johns, N. F	29.72	29.86	−.05	39.4	−1.1	46.4	32.3	44.73	− 9.90	50.6
Sydney, C. B. I	29.92	29.96	+.02	41.6	+0.3	49.7	33.4	50.56	+ 0.28	88.5
Halifax, N. S	29.86	29.97	.00	44.4	+1.6	52.5	36.4	59.12	+ 2.09	67.7
Grand Manan, N. B	29.89	29.94	−.03	43.4	+0.6	50.4	36.5	53.43	+ 6.18	69.0
Yarmouth, N. S	29.91	29.98	.00	44.4	+1.2	51.2	37.7	60.52	+10.19	55.0
Charlottetown, P. E. I	29.90	29.94	.00	41.3	+0.3	49.2	33.4	42.88	+ 1.26	92.6
Chatham, N. B	29.90	29.92	−.02	39.5	+0.8	49.7	29.3	42.90	+ 1.61	113.1

TABLE VI.—*Annual climatological summary*—Continued.

Stations.	Pressure.* Mean not reduced.	Mean reduced.	Departure from normal.	Temperature. Mean.	Departure from normal.	Mean maximum.	Mean minimum.	Precipitation. Total.	Departure from normal.	Total depth of snowfall.†
	Ins.	*Ins.*	*Ins.*	°	°	°	°	*Ins.*	*Ins.*	*Ins.*
Father Point, Que	29.91	29.93	.00	35.9	+1.1	43.2	28.6	37.68	+ 4.69	160.5
Quebec, Que	29.64	29.97	-.01	39.5	+1.3	47.5	31.5	35.16	- 6.56	108.7
Montreal, Que	29.77	29.98	-.01	43.1	+1.6	50.8	35.4	36.75	- 4.24	105.6
Bissett, Ont	29.39	30.01	+.02	37.6	-0.6	50.5	24.6	28.90	- 1.56	74.0
Ottawa, Ont	29.68	30.01	+.01	42.6	+2.0	51.6	33.6	31.60	- 1.00	72.9
Kingston, Ont	29.68	30.00	-.01	44.6	+1.5	52.4	36.8	34.43	+ 1.62	54.1
Toronto, Ont	29.63	30.01	-.01	46.0	+1.8	54.4	37.7	30.63	- 3.09	50.9
White River, Ont	28.68	30.03	+.05	31.6	-0.3	45.2	18.1	29.46	+ 4.67	98.2
Port Stanley, Ont	29.38	30.03	.00	45.5	+0.8	53.4	37.6	41.15	+ 6.73	63.2
Saugeen, Ont	29.29	30.01	.00	44.6	+2.2	52.9	36.3	35.92	+ 1.71	76.6
Parry Sound, Ont	29.27	29.97	-.03	42.2	+2.0	51.9	32.6	38.22	- 0.05	87.7
Port Arthur, Ont	29.28	30.00	.00	35.4	+1.0	44.8	26.0	22.11	- 2.65	38.8
Winnipeg, Man	29.15	30.00	.00	35.0	+1.9	46.8	23.3	16.92	- 4.06	38.9
Minnedosa, Man	28.16	30.01	+.01	34.5	+2.9	45.8	23.2	22.04	+ 5.59	43.6
Qu'Appelle, Assin	27.68	29.97	-.01	35.0	+1.7	45.8	24.2	20.09	+ 4.01	38.2
Medicine Hat, Assin	27.66	29.96	.00	41.9	+1.6	54.2	29.6	9.90	- 3.90	34.0
Swift Current, Assin	27.39	30.00	+.03	38.2	+0.7	48.9	27.4	17.93	+ 2.46	51.8
Calgary, Alberta	26.36	29.94	+.01	37.6	+0.4	49.2	25.9	22.77	+ 7.90	59.9
Banff, Alberta	25.34	29.99	+.06	35.0	+0.3	45.3	24.8	24.82	+ 2.91	102.8
Edmonton, Alberta	27.61	29.93	.00	37.6	+2.0	48.8	26.5	21.06	+ 5.23	56.4
Prince Albert, Sask	28.37	29.95	-.03	32.2	+1.7	43.4	21.0	16.87	+ 1.96	70.9
Battleford, Sask	28.23	30.00	+.03	33.8	+1.1	45.0	22.7	16.06	+ 2.13	44.7
Kamloops, B. C	28.74	29.96	+.03	46.5	-0.6	55.7	37.3	10.27	- 1.36	24.3
Victoria, B. C	29.94	30.04	+.04	49.4	+0.8	54.8	43.9	26.27	-11.87	15.9
Barkerville, B. C	25.64	29.98	+.08	35.0	-1.2	44.7	25.4	34.92	+ 1.36	118.3
Hamilton, Bermuda	29.92	30.08	-.01	70.4	+0.7	75.5	65.3	61.28	- 0.63	0.0

* Reduced to standard gravity and to the mean of twenty-four hourly observations. † For the snow year, July 1, 1902, to June 30, 1903.

TABLE VII.—*Heights of rivers referred to zeros of gages, 1903.*

Stations.	Highest water. Stage.	Date.	Lowest water. Stage.	Date.	Annual range.
Mississippi River.	*Feet.*		*Feet.*		*Feet.*
St. Paul, Minn (1)	13.5	Oct. 14	3.0	Nov. 22, 23	10.5
Red Wing, Minn (1)	11.9	Sept. 19	3.0	June 28, July 2, Dec. 9	8.9
Reeds Landing, Minn (2)	11.0	Sept. 18, 19	0.0	Feb. 24-28	11.0
La Crosse, Wis (1)	13.3	Sept. 20	3.7	Dec. 2-4	9.6
Prairie du Chien, Wis. (3)	16.7	Sept. 25	3.7	Nov. 26	13.0
Dubuque, Iowa (1)	17.4	Sept. 27	2.8	Nov. 30	14.6
Leclaire, Iowa (1)	10.8	Sept. 29, 30	0.7	Nov. 30	10.1
Davenport, Iowa (4)	13.6	Sept. 30, Oct. 1	2.0	Dec. 2	11.6
Muscatine, Iowa	14.7	Oct. 4	3.0	Nov. 30	11.7
Galland, Iowa	10.6	June 6	1.0	Feb. 9, Dec. 13	9.6
Keokuk, Iowa	19.5	June 5	1.1	Dec. 7	18.4
Hannibal, Mo	22.5	June 8	0.5	Dec. 14, 15	22.0
Grafton, Ill	28.7	June 11	2.5	Dec. 16	26.2
St. Louis, Mo	38.0	June 10	0.5	Dec. 17	37.5
Chester, Ill	33.3	June 13, 14	1.4	Dec. 18	31.9
New Madrid, Mo	39.5	Mar. 16-18	2.8	Dec. 21	36.7
Memphis, Tenn	40.1	Mar. 20	1.0	Dec. 22, 23	39.1
Helena, Ark	51.0	Mar. 25-27	2.8	Dec. 23	48.2
Arkansas City, Ark	53.0	Mar. 27, 28	2.2	Dec. 25	50.8
Greenville, Miss	49.1	Mar. 27	2.7	Dec. 25, 26	46.4
Vicksburg, Miss	51.8	Mar. 27, 28	0.2	Dec. 27, 28	51.6
New Orleans, La	20.4	Apr. 6, 7	3.0	Nov. 30	17.4
James River.					
Huron, S. Dak (5)	5.0	Mar. 12-14	0.4	Sept. 23-28, Oct. 22	4.6
Missouri River.					
Bismarck, N. Dak	12.4	Apr. 6	0.0	Nov. 21	12.4
Pierre, S. Dak (6)	9.2	June 25	1.8	Oct. 25, 26	7.4
Sioux City, Iowa (4)	13.2	July 10, 11	4.9	Nov. 17	8.3
Omaha, Nebr	14.4	June 1	4.1	Dec. 5	10.3
St. Joseph, Mo	15.0	June 2	-3.2	Dec. 16	18.2
Kansas City, Mo	35.0	June 1, 2	3.5	Dec. 16	31.5
Boonville, Mo	30.9	June 6	3.3	Dec. 19	27.6
Hermann, Mo	29.5	June 7	2.6	Dec. 16	26.9
Illinois River.					
Peoria, Ill	19.3	Mar. 12, 13	8.5	Dec. 7-9	10.8
Youghiogheny River.					
Confluence, Pa	8.3	Jan. 30	-0.4	Sept. 29, Oct. 6, Nov. 3-5	8.7
West Newton, Pa (7)	14.5	Jan. 29	0.0	Oct. 1-4	14.5
Allegheny River.					
Warren, Pa (2)	10.1	Feb. 5	0.2	June 13	9.9
Oil City, Pa	12.9	Mar. 1	0.7	June 5-10	12.2
Parker, Pa	15.0	Mar. 1	0.5	Aug. 27	14.5
Freeport, Pa	23.5	Feb. 5	1.4	Aug. 20	22.1
Clarion River.					
Clarion, Pa	11.3	Mar. 1	0.0	Nov. 12	11.3
Monongahela River.					
Weston, W. Va	14.0	Feb. 28	-1.6	Nov. 10, 11, 15, 16	15.6
Fairmont, W. Va	23.8	Feb. 28	1.0	May 21-23, July 30, Aug 4, 14-16, 25, 26, 30.	22.8
Greensboro, Pa	24.7	Mar. 1	5.4	Nov. 17	19.3
Lock No. 4, Pa	32.5	Mar. 1	6.0	July 28, Dec. 17	26.5
Conemaugh River.					
Johnstown, Pa	11.5	Feb. 28	0.4	Nov. 13-15	11.1
Red Bank Creek.					
Brookville, Pa	5.5	Jan. 30	-0.4	June 11-13	5.9

TABLE VII.—*Heights of rivers referred to zeros of gages, 1903*—Continued.

Stations.	Highest water. Stage.	Date.	Lowest water. Stage.	Date.	Annual stage.
Beaver River.	*Feet.*		*Feet.*		*Feet.*
Ellwood Junction, Pa (8)	11.0	Mar. 1	0.7	Nov. 12-16	10.3
Great Kanawha River.					
Charleston, W. Va	33.0	Mar. 24	0.1	Dec. 19	32.9
Little Kanawha River.					
Glenville, W. Va	18.6	Feb. 28	-2.9	July 29	21.5
New River.					
Radford, Va	6.3	Feb. 17	-0.5	Nov. 3	6.8
Hinton, W. Va	14.7	Mar. 24	1.1	Oct. 5-7	13.6
Cheat River.					
Rowlesburg, W. Va (8)	8.7	Mar. 1	0.6	Nov. 4, 5	8.1
Ohio River.					
Pittsburg, Pa	28.9	Mar. 1	1.6	Dec. 5	27.3
Davis Island Dam, Pa	26.5	Mar. 1	2.4	Aug. 21, Oct. 1, 2	24.1
Beaver Dam, Pa	38.1	Mar. 1	2.7	Oct. 2, 4	35.4
Wheeling, W. Va	40.2	Mar. 2	1.8	Sept. 29	38.4
Parkersburg, W. Va	39.9	Mar. 3	2.6	Oct. 7	37.3
Point Pleasant, W. Va	45.0	Mar. 4	1.5	Oct. 5-7	43.5
Huntington, W. Va	48.3	Mar. 4	4.2	Aug. 29	44.1
Catlettsburg, Ky	49.7	Mar. 4	1.5	Oct. 6, 7	48.2
Portsmouth, Ohio	51.3	Mar. 4	3.0	Oct. 7	48.3
Cincinnati, Ohio	53.2	Mar. 5	4.5	Oct. 7, Nov. 11-16	48.7
Madison, Ind	45.0	Mar. 6	3.9	Aug. 29-Sept. 1	41.1
Louisville, Ky	28.5	Mar. 9	3.0	Oct. 7, Nov. 5, 6, 11-13	25.5
Evansville, Ind	42.4	Mar. 11	2.3	Nov. 18	40.1
Paducah, Ky	47.6	Mar. 15, 16	1.6	Dec. 18, 19	46.0
Cairo, Ill	50.6	Mar. 15-17	2.9	Dec. 20	47.7
Muskingum River.					
Zanesville, Ohio	23.8	Mar. 1	5.2	Sept. 26, 27	18.6
Scioto River.					
Columbus, Ohio (8)	15.8	Mar. 1	1.6	May 22, 23	14.2
Miami River.					
Dayton, Ohio (2)	11.8	Mar. 1	0.6	Aug. 25, 28, 30, Sept 1, 2, 6, 28.	11.2
Wabash River.					
Mt. Carmel, Ill	22.3	Mar. 12	0.4	Oct. 2, 3	21.9
Licking River.					
Falmouth, Ky (2)	25.2	Feb. 16	0.2	Sept. 21-Oct. 8, 27-Nov. 4.	25.0
Kentucky River.					
High Bridge, Ky	23.7	Feb. 16, 18	8.7	Nov. 10-16	15.0
Frankfort, Ky	24.7	Feb. 17	5.0	Sept. 25-Oct. 4	19.7
Clinch River.					
Speer's Ferry, Va	17.4	Feb. 17	-1.2	Sept. 23, Oct. 6, 7, 9, 10, 13, 14, 16, 22, 23, 25, 26, 29, 30.	18.6
Clinton, Tenn	26.0	Feb. 18	2.0	Sept. 16-18, 26-28	24.0
Holston River.					
Bluff City, Tenn	9.4	Feb. 17	-0.2	Dec. 1, 7, 12, 19	9.6
Rogersville, Tenn	17.0	Feb. 17	1.1	Sept. 29-Oct. 2, 8, 14, 28-31.	15.9
French Broad River.					
Leadvale, Tenn	14.0	Apr. 8	-1.8	Sept. 10-12, 29, 30	15.8
Tennessee River.					
Knoxville, Tenn	24.6	Mar. 24, Apr. 9.	-0.5	Oct. 5-7	25.1
Kingston, Tenn	23.4	Apr. 9	0.5	Oct. 1-8	22.9
Chattanooga, Tenn	31.8	Apr. 11	0.6	Sept. 30, Oct. 7, 28-30	31.2
Bridgeport, Ala	23.4	Mar. 3	-0.1	Oct. 28-30	23.5
Florence, Ala	18.7	Mar. 6, 7	-0.5	Oct. 5-7	19.2
Riverton, Ala	31.0	Mar. 8	-2.0	Oct. 4-7	33.0
Johnsonville, Tenn	33.7	Mar. 11	-0.2	Oct. 9	33.9
Cumberland River.					
Burnside, Ky	55.1	Mar. 1	0.2	Oct. 3-6	54.9
Carthage, Tenn	36.3	Mar. 3	-0.1	Oct. 3-5	36.4
Nashville, Tenn	40.7	Mar. 9	0.7	Oct. 4, 5, Nov. 1	40.0
Clarksville, Tenn	49.6	Mar. 11	0.1	Oct. 3-6	49.5
Arkansas River.					
Wichita, Kans	7.6	June 2	0.1	Dec. 27	7.5
Webbers Falls, Ind. T	24.1	May 26	2.2	Sept. 11, 12	21.9
Fort Smith, Ark	25.1	May 26	2.0	Sept. 13	23.1
Dardanelle, Ark	23.2	June 1	1.6	Nov. 3, 4	21.6
Little Rock, Ark	24.8	June 3	3.1	Dec. 12, 22-24	21.7
White River.					
Newport, Ark	28.7	Mar. 12, 13	0.2	Nov. 29, 30	28.5
Yazoo River.					
Yazoo City, Miss	28.7	Apr. 5-8	-2.5	Nov. 1-11	31.2
Red River.					
Arthur City, Tex	28.8	July 5	4.2	Dec. 8-26	24.6
Fulton, Ark	31.2	Mar. 14	3.9	Dec. 5, 6, 11, 12	27.3
Shreveport, La	33.1	Mar. 22, 23	-2.1	Dec. 7	35.2
Alexandria, La	36.2	Mar. 27-29	-1.1	Dec. 24	37.3
Ouachita River.					
Camden, Ark	39.6	Feb. 20	3.6	Dec. 8-14	36.0
Monroe, La	44.5	Mar. 26-29	1.4	Nov. 26-Dec. 13	43.1
Atchafalaya River.					
Melville, La	38.7	Apr. 4, 5	3.9	Dec. 29	34.8
Susquehanna River.					
Binghamton, N. Y	17.6	Oct. 11	2.0	Dec. 10	15.6
Towanda, Pa	15.5	Mar. 24	0.4	June 4-11	15.1
Wilkesbarre, Pa	22.4	Mar. 25	2.9	June 4-8, 11	19.5
Harrisburg, Pa	17.1	Mar. 2	0.9	June 5-8	16.2
West Br. Susquehanna.					
Lockhaven, Pa. (8)	8.5	Mar. 1	-1.4	June 7	9.9
Williamsport, Pa	17.7	Mar. 1	0.5	June 2	17.2
Juniata River.					
Huntingdon, Pa. (7)	11.0	Feb. 4	3.0	Aug. 24, 25; Sept. 30-Oct. 5	8.0
Shenandoah River.					
Riverton, Va	10.0	June 10	-0.5	Aug. 21, Sept. 7-9; Nov. 13-Dec. 23	10.5
Potomac River.					
Cumberland, Md	8.1	Feb. 28	0.8	Sept. 30, Oct. 1	7.3
Harpers Ferry, Md	14.5	Apr. 15	-0.5	Dec. 22-26	15.0
James River.					
Lynchburg, Va	12.7	Mar. 24	0.1	Aug. 28, 29	12.6
Richmond, Va	14.7	June 8	-1.2	Oct. 18	15.9

TABLE VII.—*Heights of rivers referred to zeros of gages, 1903*—Continued.

Stations.	Highest water.		Lowest water.		Annual stage.
	Stage.	Date.	Stage.	Date.	
Roanoke River.	*Feet.*		*Feet.*		*Feet.*
Clarksville, Va	16.8	Mar. 25	2.7	Oct. 31–Nov. 3	14.1
Weldon, N. C	42.7	Mar. 26	8.8	Oct. 7	33.9
Cape Fear River.					
Fayetteville, N. C	50.5	Mar. 25	0.8	Oct. 8	49.7
Edisto, River.					
Edisto, S. C.[10]	5.9	Aug. 26	2.5	July 31	3.4
Pedee River.					
Cheraw, S. C	33.8	Mar. 24	1.4	Oct. 6–8	32.4
Black River.					
Kingstree, S. C	11.8	June 16	0.8	June 3–7	11.0
Lynch Creek.					
Effingham, S. C	13.9	June 13	3.0	July 30–Aug. 1; Oct. 8, Nov. 4–7, 13	10.9
Santee River.					
St. Stephens, S. C	15.6	Mar. 31	1.1	Oct. 9	14.5
Congaree River.					
Columbia S. C	27.2	June 9	–0.3	Dec. 20	27.5
Wateree River.					
Camden, S. C.[9]	30.4	Mar. 25	5.2	Oct. 4–8	25.2
Waccamaw River.					
Conway, S. C	6.9	Apr. 4, 5	0.6	Dec. 22	6.3
Savannah River.					
Calhoun Falls, S. C	15.3	June 7	2.0	Nov. 27–Dec. 1	13.3
Augusta, Ga	33.2	Feb. 9	6.5	Oct. 1, 13, 15, 16, 25; Nov. 1	26.7
Broad River.					
Carlton, Ga	21.0	Mar. 24	2.1	Sept. 4–6, 11–14; Oct. 28–30, Dec. 19	18.9
Flint River.					
Albany, Ga	25.0	Feb. 17	0.3	Sept. 9	24.7
Chattahoochee River.					
Oakdale, Ga	25.6	Feb. 18	0.0	Aug. 27–Sept. 9; Sept. 27–Oct. 7, 13–17, 26–31.	25.6
Westpoint, Ga	21.9	Feb. 9	2.0	Sept. 10, 11, 13, 14; Oct. 3–8, 13–16, 24–Nov. 1	19.9

TABLE VII.—*Heights of rivers referred to zeros of gages, 1903*—Continued

Stations.	Highest water.		Lowest water.		Annual range.
	Stage.	Date.	Stage.	Date.	
Ocmulgee River.	*Feet.*		*Feet.*		*Feet.*
Macon, Ga	21.2	Feb. 9	2.0	Sept. 5	19.2
Oconee River.					
Dublin, Ga	24.0	Feb. 12	–0.2	Sept. 5, 7–10	24.2
Coosa River.					
Rome, Ga	28.7	Feb. 18	0.2	Oct. 7	28.5
Gadsden, Ala	22.2	Mar. 6	–0.4	Sept. 30–Oct. 9, 15. 16, 28–30.	22.6
Alabama River.					
Montgomery, Ala	48.6	Feb. 13	0.2	Oct. 7	48.4
Selma, Ala	50.6	Feb. 15	–0.3	Oct. 7–9	50.9
Tombigbee River.					
Columbus, Miss	23.9	Feb. 12	–3.8	Sept. 23, 24	27.7
Demopolis, Ala	60.7	Feb. 22	–3.3	Oct. 13–15	64.0
Black Warrior River.					
Tuscaloosa, Ala	56.6	Feb. 17	3.6	Oct. 5	53.0
Brazos River.					
Kopperl, Tex	8.0	Feb. 26	–1.0	Feb. 11–13; Aug. 21–Sept. 1, 4–17; Nov. 15	9.0
Waco, Tex	22.0	Feb. 27	2.2	Sept. 18, 19	19.8
Booth, Tex	38.7	Mar. 7	0.7	Sept. 30	38.0
Red River of the North.					
Moorhead, Minn. ([5])	13.9	Apr. 6	7.0	Mar. 27, Aug. 24–28	6.9
Columbia River.					
Umatilla, Oreg	25.1	June 18	–0.6	Feb. 23–28	25.7
The Dalles, Oreg	43.1	June 18	1.4	Feb. 20–22	41.7
Willamette River.					
Albany, Oreg	14.0	Nov. 23	1.0	Aug. 19–22, 31; Sept. 27–Oct. 4, 27; Nov. 1	13.5
Portland, Oreg	24.0	June 18, 19	2.4	Feb. 21, Sept. 29	21.6
Sacramento River.					
Red Bluff, Cal	24.5	Nov. 22	–0.2	Sept. 18–30	24.7
Sacramento, Cal	27.6	Apr. 4	7.0	Sept. 9–18, 26, 27, 29—Oct. 1	20.6

[1] Frozen for 3 months.
[2] Frozen for 1 month.
[3] Frozen for 3¼ months.
[4] Frozen for 2¼ months.
[5] Frozen for 4 months.
[6] Frozen for 4¼ months.
[7] Frozen for 1¼ months.
[8] Frozen for 2 months.
[9] March missing.
[10] December missing.

TABLE VIII.—*Average monthly and annual departures of temperature from the normal, during 1903.*

Districts.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
New England	+0.9	+ 2.2	+8.6	+1.8	+1.4	–5.4	–0.7	–4.4	+0.5	+1.3	–2.3	–4.0	0.0
Middle Atlantic	+0.3	+ 2.1	+9.1	+1.9	+1.8	–5.2	+0.2	–2.4	–0.3	+1.2	–2.8	–4.8	+0.1
South Atlantic	–1.1	+ 1.3	+6.8	–1.1	–0.2	–3.2	+0.5	+1.7	–0.8	–0.2	–2.6	–5.5	–0.4
Florida Peninsula	+0.1	+ 2.5	+5.2	–1.9	–1.1	–0.4	+0.1	+1.5	–0.2	–0.7	–1.7	–5.0	–0.1
East Gulf	–1.3	– 1.9	+3.5	–2.4	–1.6	–4.1	–0.4	+1.5	–1.0	0.0	–2.0	–5.2	–1.2
West Gulf	+1.5	– 3.4	+1.2	–1.7	–1.9	–4.8	–1.4	+0.3	–0.8	–0.8	–0.3	–2.1	–1.3
Ohio Valley and Tennessee	–0.3	– 1.1	+7.8	–1.1	+2.7	–5.6	+0.3	+0.5	+0.8	+0.9	–3.1	–7.6	–0.5
Lower Lakes	0.0	+ 0.8	+9.8	+1.5	+3.4	–4.7	–0.5	–2.6	+1.2	+2.0	–1.9	–6.8	+0.2
Upper Lakes	+2.0	+ 1.3	+9.0	+2.0	+2.8	–3.0	–0.2	–3.0	–0.3	+2.5	–0.8	–7.0	+0.2
North Dakota	+6.1	– 4.8	+3.0	+2.0	+1.8	–1.7	–1.9	–2.5	–4.9	+4.2	+1.8	+0.8	+0.3
Upper Mississippi Valley	+3.7	– 1.7	+6.5	+0.6	+2.5	–4.5	–0.4	–1.7	–1.0	+1.9	–0.9	–6.5	–0.1
Missouri Valley	+5.7	– 3.8	+3.5	+0.6	+1.5	–4.0	–0.4	–1.2	–2.6	+2.7	0.0	–2.8	0.0
Northern Slope	+8.9	– 4.1	–2.2	–0.2	–1.4	–0.2	–1.6	–0.3	–2.8	+4.1	0.0	+4.9	+0.2
Middle Slope	+5.3	– 5.5	+0.2	–0.4	–1.6	–5.0	+1.2	+0.9	–1.7	+1.4	+1.1	+1.4	–0.2
Southern Slope	+2.4	– 4.3	–1.0	–0.5	–2.8	–6.3	+1.9	+1.6	–1.4	–0.1	+0.4	+1.6	–0.7
Southern Plateau	+2.7	– 6.1	–1.0	–1.3	–2.0	–2.4	–1.9	+0.7	–1.9	+0.5	+2.9	+0.2	–0.8
Middle Plateau	+1.5	–13.0	–0.9	–2.1	–3.0	+0.3	–3.0	–0.4	–3.4	+2.4	+2.2	+0.6	–1.6
Northern Plateau	+5.8	– 3.0	+0.2	–2.1	–1.2	+5.0	–2.6	–0.4	–1.6	+2.1	+0.6	+0.2	+0.2
North Pacific	+3.2	– 0.3	–2.1	–1.9	–1.4	+1.6	–2.0	–0.6	–0.1	+1.8	+0.6	+0.6	0.0
Middle Pacific	–0.2	– 2.7	–1.4	–1.4	–0.5	+1.4	–2.5	–1.3	+0.5	+3.4	+1.0	+1.4	–0.2
South Pacific	+2.5	– 3.7	0.0	–1.3	–1.0	+1.0	–2.4	–0.6	+0.4	+1.8	+2.6	+1.5	+0.1

TABLE IX.—*Monthly and annual departures of precipitation from the normal, during 1903.*

Districts.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
New England	−0.3	+0.4	+1.8	+0.2	−2.7	+2.2	−0.7	−0.5	−1.6	−0.8	−1.7	−0.5	−4.3
Middle Atlantic	−0.2	+0.8	+0.9	−0.5	−2.4	+1.4	+0.3	+1.4	−1.7	+2.5	−1.6	−0.7	0.0
South Atlantic	−0.4	+1.4	+0.6	−0.4	+0.1	+0.8	−2.3	+1.0	−1.6	−0.9	−0.8	−1.6	−4.4
Florida Peninsula	+2.7	+2.1	+3.0	−1.7	+1.3	−1.2	−0.8	−0.8	+1.4	−3.0	+0.5	−0.9	+2.6
East Gulf	−1.0	+5.7	+1.9	−3.1	−1.0	−1.4	−0.5	−1.1	−2.4	−0.8	−1.5	−1.6	−7.0
West Gulf	−0.9	+2.9	+1.4	−2.7	−1.0	−0.7	+3.9	−0.6	−2.2	−0.1	−3.6	−1.3	−5.0
Ohio Valley and Tennessee	−1.9	+1.8	+0.3	−0.1	−0.4	−0.5	−1.5	−0.7	−2.0	−0.4	−1.0	−1.3	−7.8
Lower Lakes	−0.4	+0.6	+0.2	+1.6	−2.0	+0.7	+1.0	+1.6	−1.1	−0.2	−1.6	−0.5	−0.1
Upper Lakes	−0.8	−0.1	+0.3	+0.4	−0.2	−2.0	+1.7	+1.6	+0.5	−0.6	−0.8	−0.6	−0.6
North Dakota	+0.2	−0.4	−0.4	−1.0	+0.8	−2.2	−0.6	+0.3	+1.9	0.0	−0.4	+0.1	−1.7
Upper Mississippi Valley	−0.9	−0.1	0.0	+0.4	+0.9	−2.2	+0.4	+1.9	+1.2	0.0	−1.4	−0.9	−0.5
Missouri Valley	−0.5	+0.2	−0.3	−0.4	+2.8	−1.4	−0.2	+3.1	+0.6	+0.2	−0.3	−0.5	+3.5
Northern Slope	−0.3	+0.2	0.0	0.0	−0.2	−0.5	+0.8	+0.6	+0.5	−0.5	−0.1	−0.3	+0.4
Middle Slope	−0.6	+0.8	0.0	−0.4	+2.4	−0.8	−1.0	+0.3	−0.6	+0.9	−0.4	−0.7	−0.2
Southern Slope	−0.5	+2.3	+0.4	−1.3	−0.6	−0.8	−1.5	+0.7	+0.1	−1.0	−1.4	−1.2	−4.8
Southern Plateau	−0.8	−0.1	+0.4	+0.4	−0.1	+0.9	−0.4	−0.3	+0.9	−0.4	−0.6	−1.2	−1.3
Middle Plateau	+0.1	−0.3	+0.1	+0.1	+0.1	0.0	−0.1	−0.4	+0.2	−0.4	0.0	−1.1	−1.7
Northern Plateau	−0.4	−1.3	−0.1	−0.5	−0.8	−0.2	−0.3	+0.6	0.0	−0.4	+0.9	−0.7	−3.2
North Pacific	−0.5	−3.7	−0.4	−1.6	−0.6	+0.2	−0.1	0.0	+0.1	−1.6	+3.5	−4.1	−8.2
Middle Pacific	+0.3	−2.1	+1.5	−1.8	−1.2	−0.4	0.0	0.0	−0.7	−1.0	+2.9	−2.7	−5.4
South Pacific	−0.6	−0.7	+1.6	+0.5	−0.3	−0.1	0.0	0.0	0.0	−0.6	..1.0	−2.8	−4.2

TABLE X.—*Monthly and annual departures of relative humidity from the normal, during 1903.*

Districts.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
New England	−2	−2	+7	−1	−7	+4	−2	−1	−2	0	−5	−3	0
Middle Atlantic	0	−2	+7	0	−3	+6	−1	+5	+2	−1	−4	−6	0
South Atlantic	0	−4	+6	−3	+2	0	−4	0	−2	0	−2	−10	−1
Florida Peninsula	+2	−2	+6	−4	−3	−2	−1	−2	−3	−5	+1	−3	−1
East Gulf	−1	−1	+11	+3	+7	0	−1	+1	−5	−2	−2	−9	+1
West Gulf	0	+6	+6	−4	+2	−2	+4	+3	−2	−1	−7	−7	0
Ohio Valley and Tennessee	0	+3	+8	+4	−2	+4	+1	+2	−3	0	0	−2	+1
Lower Lakes	+1	+1	+7	+3	−6	+6	+3	+4	+1	+1	−3	+3	+2
Upper Lakes	0	−1	+3	−3	0	−2	+2	+3	0	−2	−4	−1	−1
North Dakota	−3	−5	−2	−2	−3	−4	+1	+10	−9	−4	−4	−1	0
Upper Mississippi Valley	+2	+3	+5	0	+3	0	+1	+6	−4	+3	0	−2	+2
Missouri Valley	+1	+4	+5	−2	+6	+2	0	+7	−4	−3	0	0	+3
Northern Slope	+4	+11	+5	+4	+6	+6	+9	+12	+9	+2	+7	+5	+7
Middle Slope	+1	+10	+14	+3	+8	+9	0	+5	+2	+1	+7	−4	+4
Southern Slope	+2	+8	+17	0	+5	+13	−1	0	+5	+1	0	−8	+2
Southern Plateau	−4	+5	+4	+3	+3	+10	−5	−1	+3	−5	−5	−9	0
Middle Plateau	+2	+15	+6	+6	0	+3	+2	+2	+5	−3	+8	−5	+3
Northern Plateau	+3	−3	+2	+2	−2	+1	+8	+1	+7	−2	+4	+3	+1
North Pacific	0	−7	0	0	+1	+8	+2	+1	−2	0	0	+1	0
Middle Pacific	+5	−8	+2	−4	−5	−1	−1	−1	−5	−2	+7	−5	−2
South Pacific	−3	−3	+3	+3	+1	+2	+3	0	0	−2	+2	−9	0

TABLE XI.—*Monthly and annual departures of average cloudiness from the normal, during 1903.*

Districts.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
New England	−0.3	−0.1	+0.4	−0.1	−1.9	+1.9	+0.4	+0.7	−1.0	+0.3	−0.4	−0.2	0.0
Middle Atlantic	+0.5	−0.3	+0.8	+0.2	−1.0	+1.6	−0.6	+1.1	−0.8	+0.8	−0.2	−0.3	+0.1
South Atlantic	+0.7	+0.4	+1.8	+0.4	+0.8	+0.5	−1.2	−0.3	−0.6	0.0	+0.4	−1.1	+0.3
Florida Peninsula	+1.7	+1.0	+1.5	−0.4	−0.4	−0.1	−0.1	−0.7	0.0	−0.2	−0.8	−0.8	0.0
East Gulf	+0.6	+1.4	+2.8	−0.1	+1.5	+0.6	+0.2	+0.4	−1.5	−0.1	−0.1	−1.6	+0.3
West Gulf	+0.8	+0.7	+1.1	−0.7	+0.6	+0.1	+0.1	−0.4	−0.6	+0.3	−0.3	−1.0	0.0
Ohio Valley and Tennessee	+0.2	−0.2	+1.1	+0.7	−0.1	+0.6	−0.2	+0.1	−1.2	−0.5	−0.1	−1.0	0.0
Lower Lakes	+0.3	−0.4	+0.2	−0.3	−1.5	+0.9	+0.1	+1.0	−0.8	−0.2	−0.5	+0.8	0.0
Upper Lakes	+0.2	−0.5	+0.6	+0.1	−0.1	0.0	+0.3	+1.3	+0.5	−1.4	−0.3	+0.2	0.0
North Dakota	+0.6	−2.1	+0.1	−0.8	−0.2	−1.0	+0.1	+1.2	+1.2	−1.3	−0.2	+0.5	−0.1
Upper Mississippi Valley	+0.5	+0.1	+0.5	+0.4	+0.8	−0.2	−0.2	+1.0	+0.2	−0.7	−0.2	−0.2	+0.2
Missouri Valley	−0.1	−0.5	−0.1	−0.4	+0.2	+0.1	+0.1	+0.7	+0.9	−0.1	+0.7	−0.1	+0.2
Northern Slope	+0.2	−0.4	0.0	−0.4	+0.1	0.0	+0.5	−0.1	+0.7	−0.9	+0.5	0.0	0.0
Middle Slope	+0.8	+0.4	+0.8	−0.2	+1.1	+2.0	−0.3	0.0	+0.5	+0.5	+0.7	−1.2	+0.5
Southern Slope	+0.6	+1.6	−0.2	+0.7	+0.3	+1.8	−0.1	−0.5	+0.6	+1.0	−0.5	−0.8	+0.4
Southern Plateau	+0.5	+0.3	+1.1	+0.5	+0.8	+1.1	−0.9	−0.3	+0.7	−1.2	0.0	−1.0	+0.2
Middle Plateau	−0.2	−1.4	+0.8	−0.3	−0.1	−0.5	+0.2	−0.6	−0.1	−0.6	+0.7	−2.4	−0.2
Northern Plateau	+0.5	−1.9	−0.3	−0.6	−0.6	−0.4	+0.3	−0.7	+0.2	−0.9	+1.3	−1.0	−0.4
North Pacific	+1.1	−1.5	−0.5	+0.3	+0.8	+0.8	+1.2	+1.9	+0.6	−0.1	+1.9	0.0	+0.5
Middle Pacific	+1.3	−1.0	+1.9	−1.3	−1.3	+0.1	+0.3	+0.5	+0.3	+0.4	+2.8	−1.4	+0.2
South Pacific	+0.5	−1.1	+0.9	0.0	+0.2	+0.5	+0.8	−0.7	+0.5	−1.0	+1.2	−2.0	−0.2

Chart I. Sea-Level Pressure and Temperature; Resultant Surface Wind, 1903.

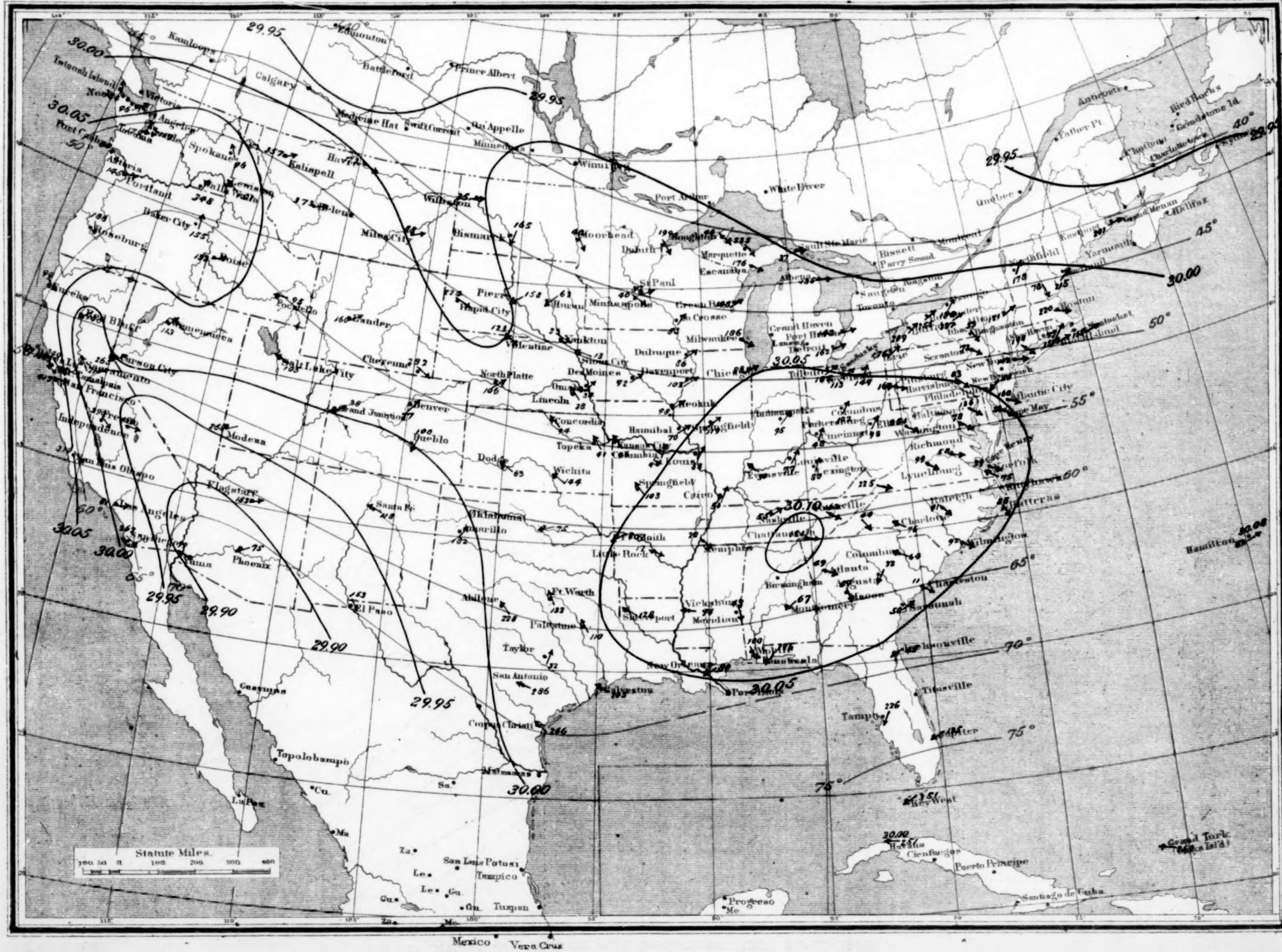


Chart II. Isobars and Isotherms (3500 feet), 1903.

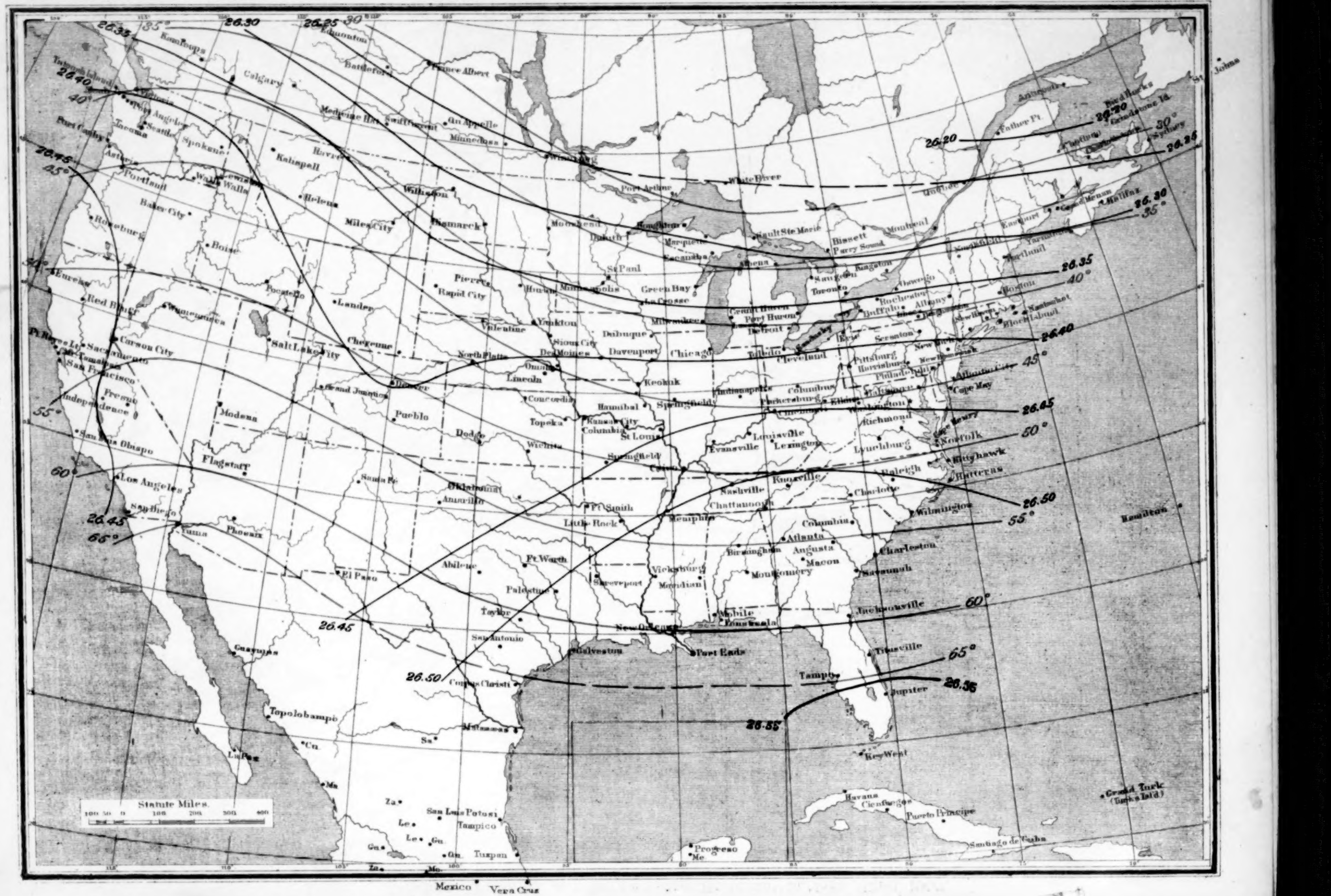


Chart III. Isobars and Isotherms (10,000 feet), 1903.

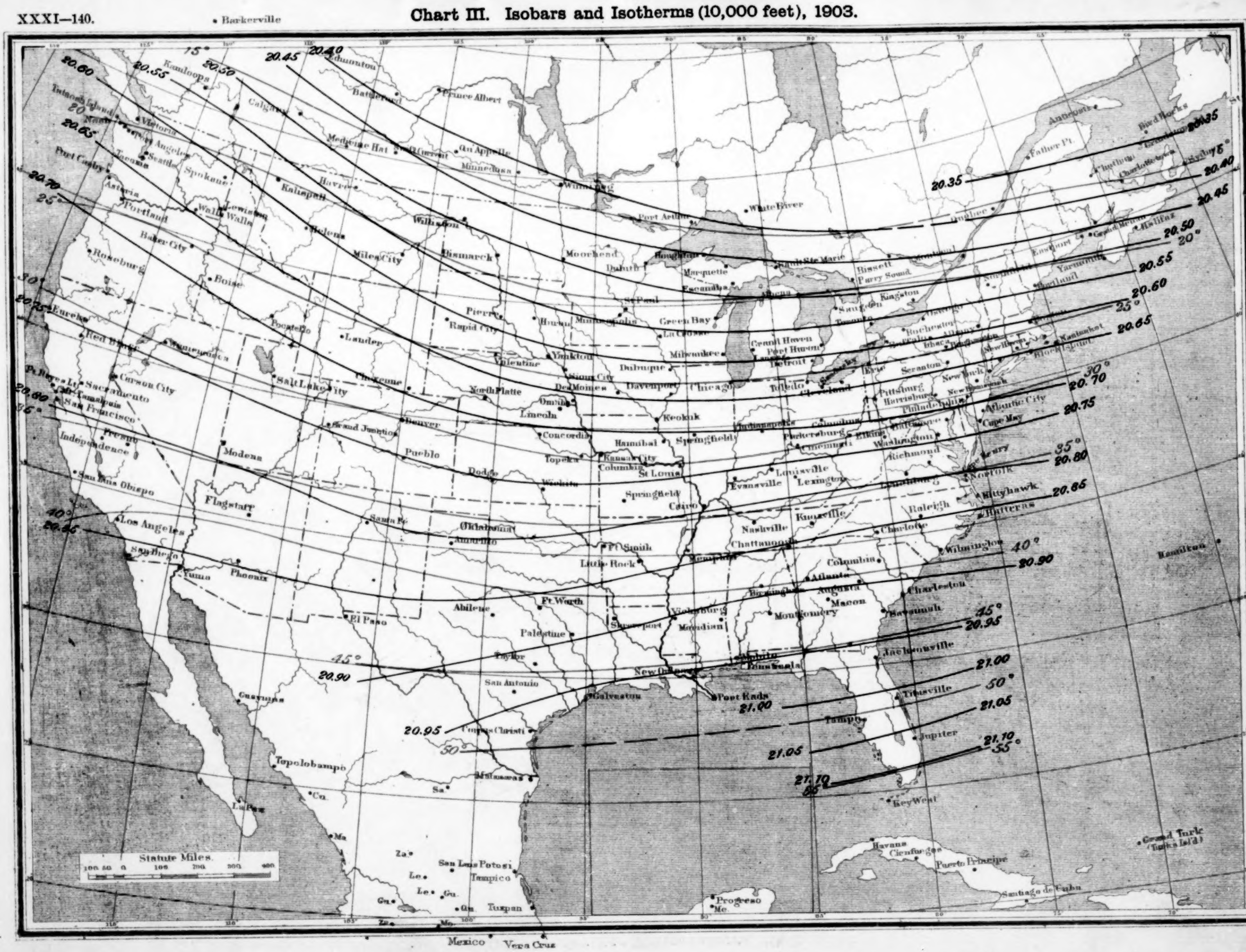


Chart IV. Surface Temperatures, 1903.

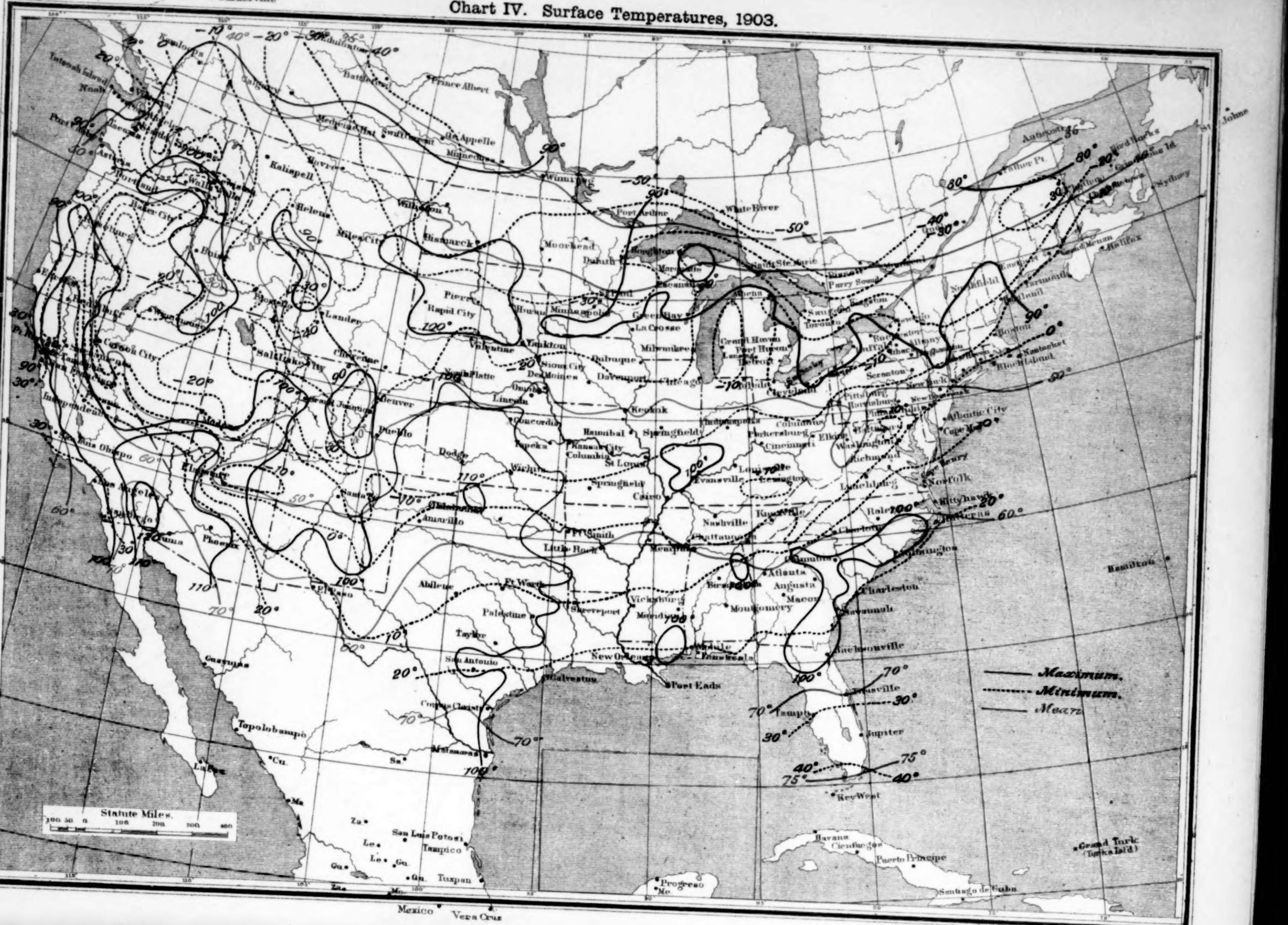


Chart V. Total Annual Precipitation, 1903.

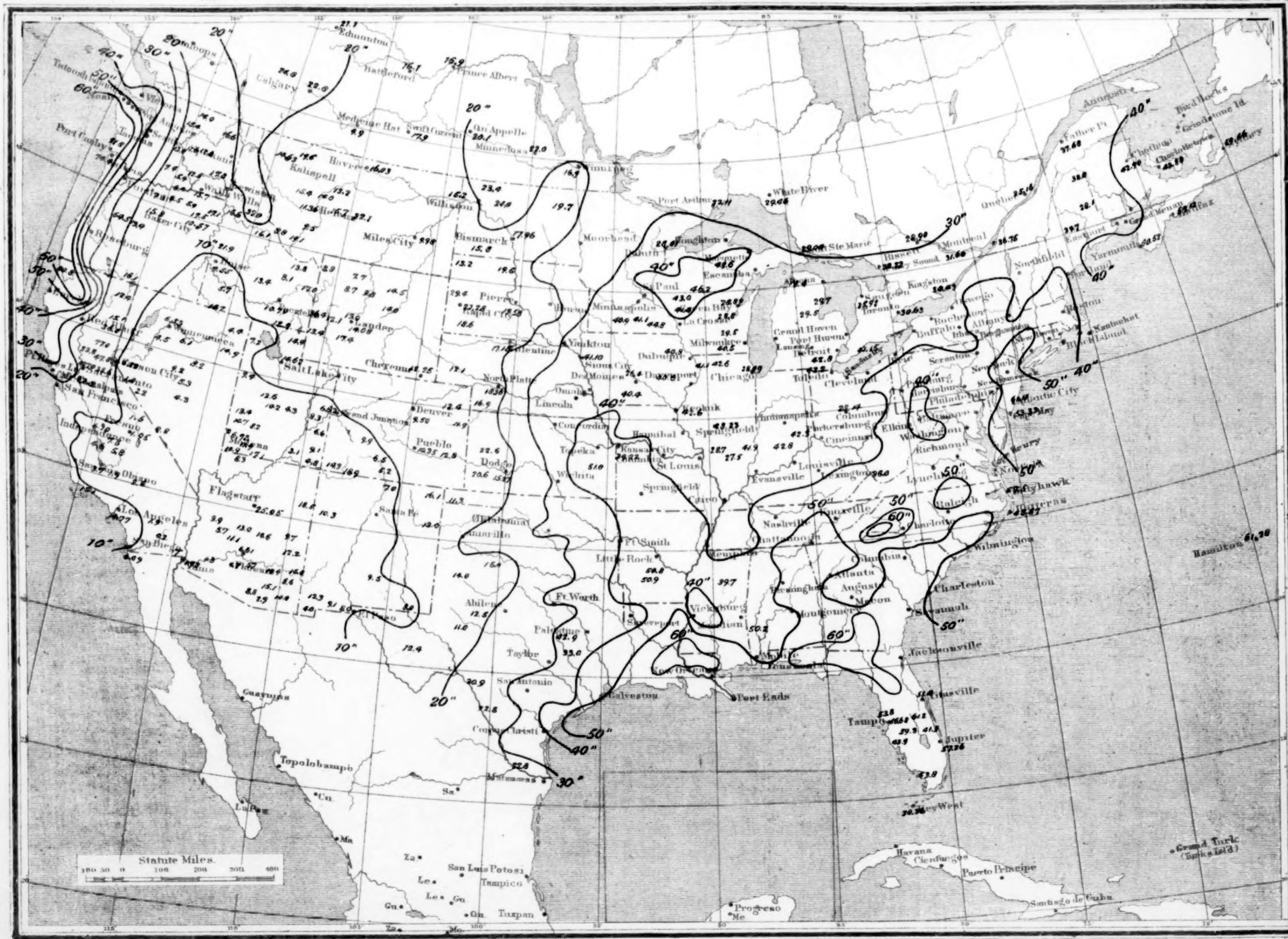


Chart VI. Total Number of Thunderstorm Days, 1903.

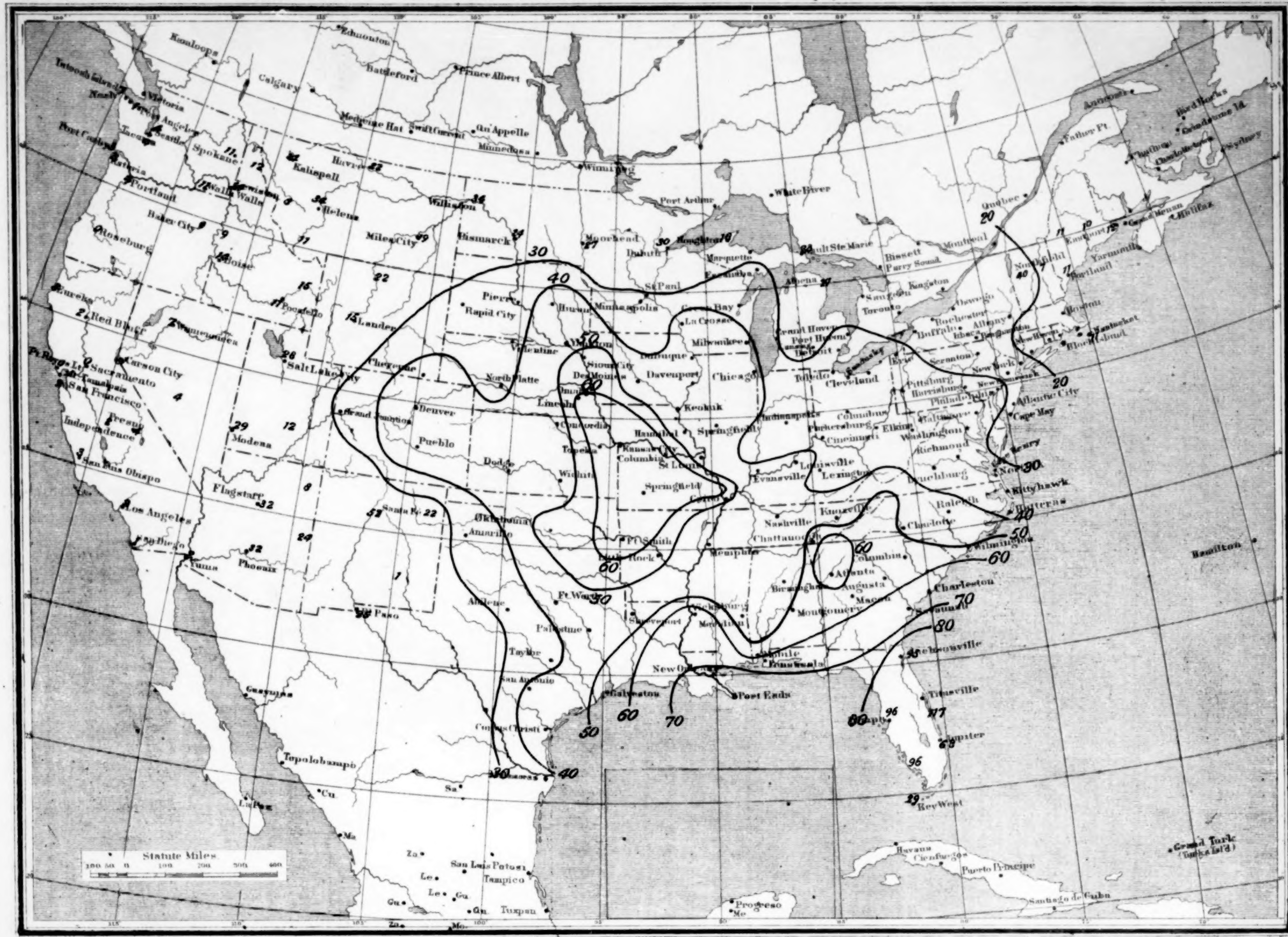


Chart VII. Percentage of Sunshine, 1903.

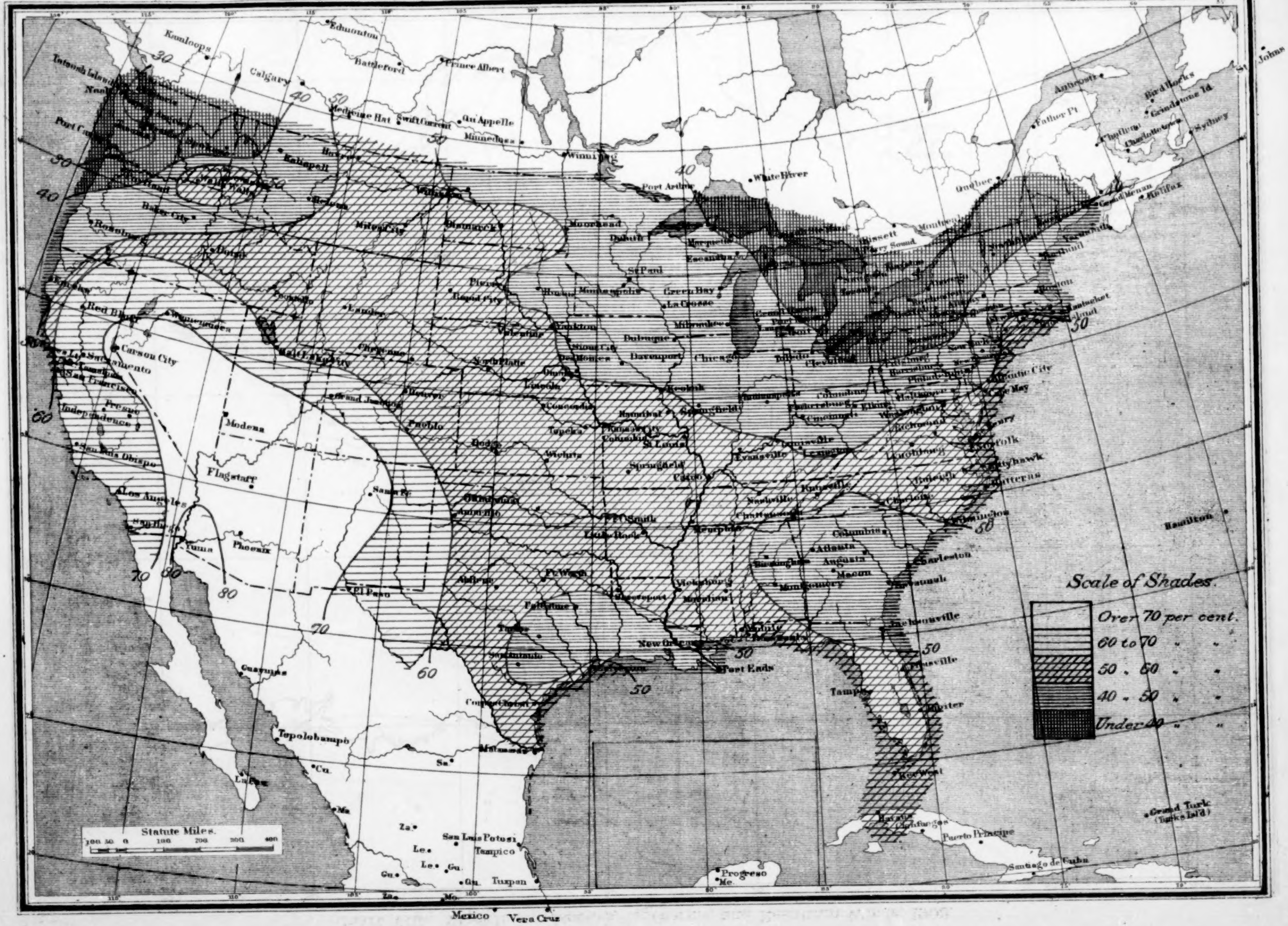
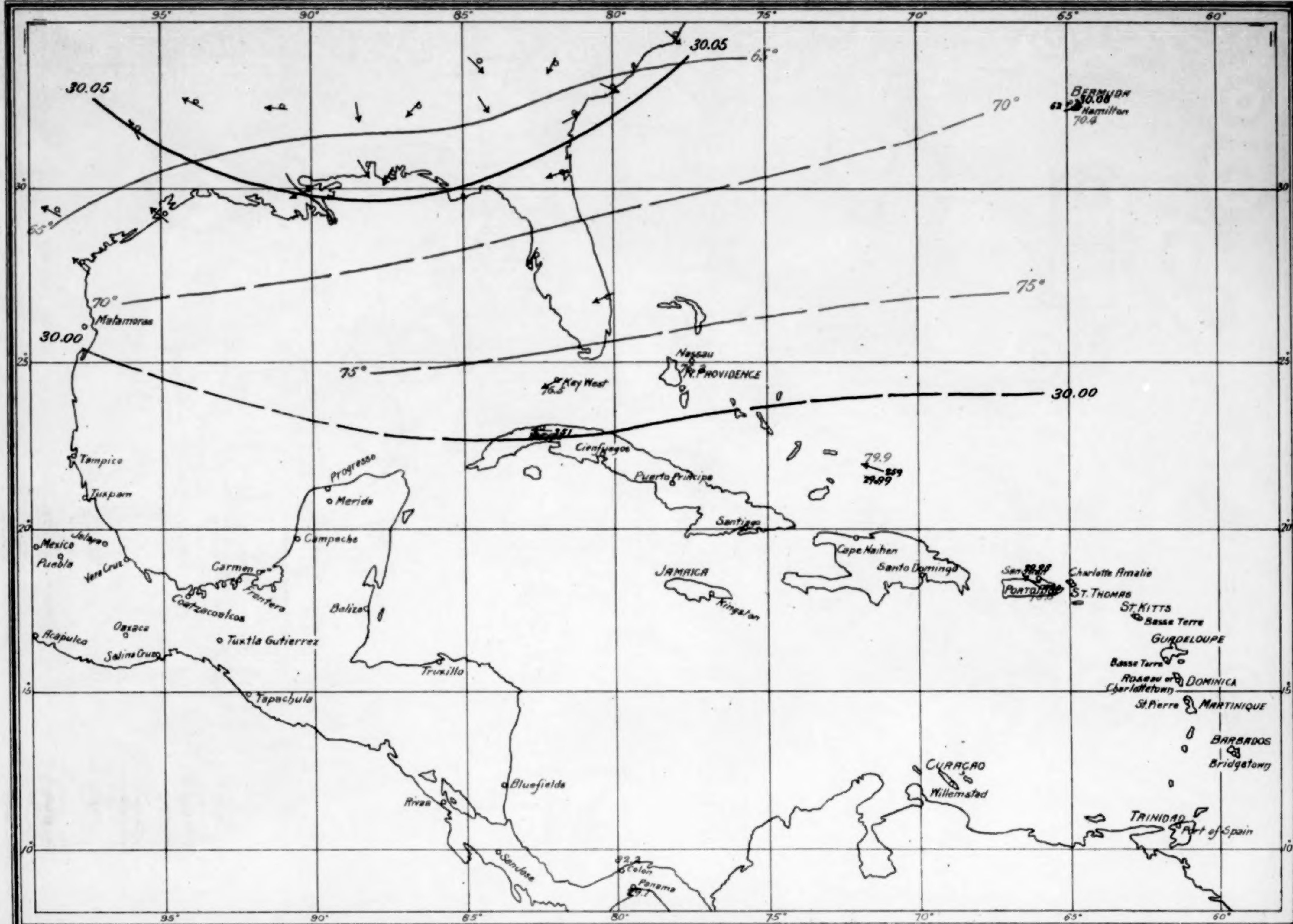


Chart VIII. West Indian Isobars, Isotherms, and Resultant Winds, 1903.



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